This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

60

SCENE IN A PINE FOREST.

[illegible]

THE

BOTANIC ANNUAL.

GENERAL PRINCIPLES—CONIFERÆ.

ARAUCARIA IMBRICATA (CHILI PINE) IN THE ROYAL GARDENS, KEW.

Height, 11 feet; spread of the branches, 11 feet; diameter of the stem, 6 inches.

LONDON:
JAMES COCHRANE AND CO.
WATERLOO PLACE, REGENT STREET.

THE

BOTANIC ANNUAL;

OR,

FAMILIAR ILLUSTRATIONS

OF THE

STRUCTURE, HABITS, ECONOMY, GEOGRAPHY, CLASSIFICATION,

AND PRINCIPAL USES

OF

PLANTS,

WITH NOTICES OF THE WAY IN WHICH THEY ARE AFFECTED

BY CLIMATE AND SEASONS;

AND

A SHORT SKETCH OF CONIFERÆ.

BY ROBERT MUDIE,

AUTHOR OF "THE BRITISH NATURALIST," &c.

"God said, I have given you every herb that is upon the face of all the earth, and every tree."—Genesis.

LONDON:
PUBLISHED BY JAMES COCHRANE AND CO.,
WATERLOO PLACE, PALL MALL.

1832.

J. Westley and Co., 27, Ivy Lane.

PREFACE.

The author of a book seldom gets credit for sincerity when he prefaces it by an apology; and, perhaps, as seldom deserves credit, because his own belief that the book is a good one is the only plea of justification for his publishing it at all. When, however, an author, laying no claim to professional knowledge, or status of any kind, writes upon a subject highly interesting in itself, and in the investigation of which some of the ablest men of the time are zealously and successfully employed, explanation becomes absolutely necessary. Part of the explanation why the present volume appears, is to be found in the reception which "The British Naturalist" met with from the public. Part, also, may be attributed to the regard which the Author has for the subject, and the pleasure that he has derived from the silent and unobtrusive study of it during the few leisure hours of more than twenty years of laborious occupation. As he felt one day in the field or the forest, or by the flood, in converse with the growing and moving inhabitants, and in contemplation of the circumstances by which the characters of these are evolved and modified, an abundant solace for incessant confinement and occupation during the rest of his time; and as he so felt, without any predisposing aptitude or acquirement, but solely from the pleasure of the contemplation of grouped nature itself, it was, probably, not very presumptuous to conclude that he might contrive to impart, to a few printed notes on the subject, some traces of the feeling by which he himself had been so frequently and so delightfully affected. The little work already alluded to in so far justified that presumption, and led him to hope that something similar might be done in the equally fascinating, and more generally accessible, subject of plants.

It was in this hope that "The Botanic Annual" was planned and executed, at an expense of more research, and labour, and weighing of opinions, than most who read books, and many who prepare them for the printer, would be willing to believe.

The volume has no pretensions to system, for that would have defeated the very object in view;

and it has little pretension to the adding of new matter, or enlarging the sphere of botanical knowledge, because that must be done by actual observation of the subjects; and no individual could, by possibility, examine in their native localities, and under the circumstances that form their habits and regulate their duration, even one tenth of the few that are noticed in the following pages, scattered as they are over almost every region of the globe. In as far as British plants, in their native localities, are concerned, the Author writes from his own personal observation, and therefore stands by what he advances; and, in the other and larger portion, he has done what he could to avail himself of the best authorities, printed, in manuscript, or oral. On some minor points he has felt justified in departing from the usually received opinions; but, as he has done so from conviction, he trusts he has also done it with candour. To those who look for a mere catalogue, and wish for nothing further than the humble attainment of calling plants by their names, it may seem that too much of the volume has been devoted to general matters. These, however, are the really important ones; and it is because the knowledge of plants is too frequently taken away from those connexions that give it the substance and the charm of philosophy, that it becomes a dead letter instead of a living word.

In some places there may appear to be repetitions; but when the end in view is to group the subjects of knowledge, and make the one throw light upon the other, some repetition is unavoidable. To explain the very first topics, an allusion to other topics that are unexplained, is unavoidable. That is the case even in those sciences which are considered as being the most precise and limited in their subjects. A geometer can neither understand Euclid's definition of a point himself, nor make any one else understand it, without direct and complete reference to a solid; and if that be the case in a purely abstract science, much more must it be the case in one that is mixed and descriptive.

In the sketch of the coniferæ more attention has been paid to the geographical distribution of the plants, and the reciprocal effects that take place between them and climates and soils, than to the merely botanical characters. To have given the latter would have been a third—in some instances, a thirtieth—repetition of the same tale, either taken in the words of its rightful owner, or turned into words, in all probability, less appropriate. To do the former is to bring from many sources the elements whence general conclusions may be drawn. In most cases the actual drawing of the conclusion is left to the reader, that he may have the pleasure of his thought, and the enjoyment of his victory; and where the conclusion is hinted at, every care has been taken that it should be on the safe side, and not dogmatical. The most mischievous of all conclusions are those which conclude the reader's desire to know any more of the subject, and it were pity to increase them, as they are somewhat too numerous already.

The illustrative engravings have been obtained from actual specimens, where these could be obtained in a proper state, and in the others from the most esteemed authorities; and it is hoped that they will be found as accurate as the style in which they are executed will admit. To have done them more expensively would have defeated the purpose of the book, by rendering it too expensive; and to have added many in the second and third sub-orders of the coniferæ would have been, from the nature of the subjects, additional expense without any additional value.

Though, in accordance with the fashion of the time, this little work is styled an "*Annual*," the reader must not expect to find in it those "rainbow tints from countless rills," of which one really knows not whether most to admire the "imponderable floatiness," or mourn the evanescence. Although some of the subjects treated of are deciduous, all of them last for seasons; and such is the intention of the book, whatever may be its chance in a world of chancings.

Should the present volume meet with that encouragement which the Author has been anxious to deserve, it will, after a reasonable pause, be followed by another one, in which the orders of plants first sketched will be the GRASSES and the PALMS; the first of which will bring before the reader the general green carpeting by which temperate climates are rendered so delightful; the second will involve a delineation of the forest scenery of tropical countries; and the two together will disclose the sources whence men, in almost every clime, derive the most essential part of their vegetable food, and very many of their most valuable accommodations. In the meantime, however, the fate of the present volume is in the scale, and upon that the future must depend.

Kew, December 1, 1831.

ANALYSIS OF THE CONTENTS.

CHAPTER I.—INTRODUCTION.

Page

The study of Nature—its fascinations—it is boundless—the province of the naked eye—of the microscope—of the telescope—of imagination—the inference and moral utility—the practical uses—the intellectual use—books and book-makers — observation—divisions of natural subjects—the living—the dead—crystallization —organization—volume and activity. . . . . 1—22

CHAPTER II.—INDUCEMENTS TO STUDY PLANTS.

Plants are beautiful—accessible—cleanly—the study of them healthy—they are found every where—at all seasons—wisdom of Solomon—trees—the village tree—it is a kalendar—a record of seasons and events — its seasonal changes—heat and humidity—epochs of vegetation—general causes that affect plants—latitude—elevation—rain—particulars of these . . . . . . 23—52

CHAPTER III.—SCIENCE AND STUDY OF PLANTS.

Definition of "BOTANY"—points to be known—external appearance — economy — habitat—constituent parts—products—uses—culture—divisions of the science—anatomy—physiology—descriptive history—the last is properly "botany"—phenogamous plants—cryptogamous plants—vascular plants—cellular plants—endogenous—exogenous — monocotyledonous — dicotyledonous—the connexions and distinctions of those terms 53—72

CHAPTER IV.—ANATOMY OF PLANTS.

Organs of plants must not be confounded with those of animals. . . . . 73—75

SECTION I.—CONSTITUENT STRUCTURES.

Cells—vessels—cellular substance — minuteness of the cells—their functions—vascular substance—two hundred and forty millions of vessels in one foot of an oak —forms of the vessels—kinds of vessels—fasciculi of vessels—action of vessels—seasonal action—peculiar actions . . . . 75—87

SECTION II.—NATURAL STRUCTURES.

Pith—its formation and use—mistakes respecting it — radiated texture—the wood—in ligneous stems — in those that are mostly cellular—trees—the turnip bulb —pollens—production of different kinds of wood— bark— in trees—in herbs—epidermis—pores—follicles 85—105

SECTION III.—MEMBERS OF PLANTS.

Roots — kinds of roots — rootlets — stems — stalks—branches and branchings—hollow stems—tabasheer—pollarding—appendages—thorns—holdfasts — the ivy —buds—kinds of buds—propago—gongylus—bulb—germ—structure of buds—leaves—the shade of trees—kinds and duration of leaves—flowers—parts of flowers — achlamydous — monochlamydous—dichlamydous anther— ovary—*gamos*—organization— seeds—parts of seeds—germen—corculum—radicle — plume — cotyledons—durability of most seeds . . . . 105—156

CHAPTER V.—PHYSIOLOGY OF PLANTS.

Introductory remarks—idolatry in Hindoos—in philosophers—Carmauian partridges—prophetic moths . . 156—162

SECTION I.—LIFE OF PLANTS.

What is life ?—laws of life—organization—is transmitted —consists not in the properties of the organized body as physical—Lucretius—modern Lucretii—remarks on the latter—life cannot be studied but in its developments . . . . 162—168

SECTION II.—GERMINATION.

Primary step—initiatory agents—effects of heat and moisture—second step—organic development —radicle—plume—third step—effect of air and light—remarkable case of a potatoe . . . . 168—176

SECTION III.—VEGETATION.

Vegetable action in trees—vessels and their functions—formation of bark and wood—the sap in the wood—is there a circulation?—analysis of sap—sap in the alburnum—sap in the twigs and leaves—pores (culs de sac?)—atomic action—sap in the leaves—action of leaves—formation of cambium—of new wood and bark—ripening of the wood—absorption and exhalation—peculiar products—healing power—green colour and its formation—a remark on M. Senebier—hints toward a hypothesis of vegetable colours. . . . . 176—202

SECTION IV.—FUNCTIONS OF ORGANS.

Calices and corollas—more hints on colours—sap in the petals of flowers—odour and flower—organic changes—cause of abundant flowering—chemical composition of flowers—their temperature—seeds . . . . . 202—216

SECTION V.

Motion of plants—sleep—decay. . . . . 216—218

CHAPTER VI.—CLASSIFICATION OF PLANTS.

There is no perfect system—obstacles to the forming of one—life—uncertainty of our knowledge—ignorance of relations—difficulty in finding names—old names—modern names—complimentary names—Adam naming the beasts and birds—parenthetical note on geographical nomenclature—confusion of names—Linnæan system—outline of it—its advantages and disadvantages

—natural system—in what it differs from the Linnæan —its grand advantage—what is a natural system?—instance of one in geometry—natural classes—natural orders—genera—species—orders and genera artificial—there are probably too many orders in the present natural system — foundations of natural characters — grounds of specific characters—agreement of the leaf and the structure—conclusion . . . . 218—276

CHAPTER VII.—SKETCH OF THE CONIFERÆ.

The coniferæ, an advantageous order to commence with —they are striking—abundant—useful—their timber —their resin . . . . 277—280

SECTION I.—GENERAL CHARACTER.

Their coincidences—pollen vessels—cones—leaves—budding and branching—uses in the economy of Nature 280—293

SECTION II.—NUMBERS AND SUB-ORDERS.

Number of species — geographical distribution — arrangement into sub-orders . . . . 293—295

SUB-ORDER, ABIETINÆ.

§ 1. *Araucarias.*

Of Chili—of Brazil—of New Holland—of Norfolk Island —their habits—their timber and uses . . . . . 293—303

§ 2. *Dammaras.*

Of Amboyna—of New Zealand—Dammar resin—their habits—timber—uses . . . . 303—309

§ 3. *Spruces.*

Numbers and distribution—general habits, timber and products—spruces of Europe—of Asia—of America 309—333

§ 4. *Pines.*

Numbers and distribution—general habits and properties—pines of Europe—of Asia—of Africa—of America 333—362

§ 5. *Larches.*

Geographical distribution—characters—differences from the pines—larches of Europe—of Asia—of America—timber and products of larch . . . . 362—376

§ 6. *Cedars.*

General characters—aspect—localities—cedar of Lebanon—timber of the cedar—variability of its annual growth—mistakes about it—the deodara—durability of its timber . . . . 376—398

SUB-ORDER, CUPRESSINÆ.

Distribution—general characters—hardiness . . . . 398—403

§ 1. *Cypresses.*

Numbers—evergreen—cedar of Goa—other species . 404—410

§ 2. *Taxodium.*

Taxodium disticha . . . . 410—412

§ 3. *Arbor-vitæ.*

Chinese—American—Cape—other species . . . . 413—417

§ 4. *Junipers.*

Numbers and distribution—European junipers—uses—Asiatic junipers—African junipers—American junipers—red cedar—pencil cedar . . . . 418—429

§ 5. *Callitris.*

Characters—habits . . . . 429—430

§ 6. *Ephedra.*

Characters—situations . . . . 430—431

SUB-ORDER, TAXINÆ.

General characters — localities — timber—treatment of young trees—genera . . . . 431—434

Common yew — remarkable yew—podocarpus— dacrydium—kakataro—phyllocladus . . . . 434—445

POPULAR BOTANY.

CHAPTER I.

INTRODUCTION.

THE cheapest, the most accessible, and, at the same time, the most instructive and delightful, of all studies, is the study of Nature. The student of literature must have his library, the natural philosopher or the chemist his apparatus, and the student of man his annals and records, which are always imperfect, and the greater part of his time must be spent in establishing their truth or detecting their falsehood. All these must be out of the living world, as it were—must abstract themselves from the sun, the sky, the earth, and the sea, and keep aloof from the charms and fascinations of that world of wonders, that creation of beauties and utilities, which is so abundant, so universal, and so fitted for the gratification of the human mind, that the very first time that an infant exercises its feet upon the sward, or stretches its arms in the open air, it is to chase butterflies or cull wild flowers. And, unless where the enchantments of society allure, or the hardships of life compel, this, the first and fondest attraction, retains its freshness to the last. If pleasure, unmixed with forecastings of retributive bitterness, is sought—if the body is to be recruited after the exhaustion of disease—if the wounded spirit is to be healed after the anguish of privation or the agony of misfortune—nay, if there is any hope that reason shall resume her power, after the pressure on the mind has been more than its strength,—the "joy that bringeth no sorrow"—the medicine for the disease—the balm for the wounded spirit—the asylum for the wandering mind—are found no where but in the sunny glades, the green canopies, and the life-imparting breezes of nature. So, also, when the strength has failed, and the common occupations of life can no longer be followed, and its common amusements can no longer give pleasure—when wealth becomes uneasiness, honour a burden, the banquet palls on the appetite, and the ear is dull to the sounds of music, and the eye dim to all the panoply of grandeur—place but the sufferer in society upon a green slope, where the landscape spreads wide and full before him, with its clustering woods, its opening glades, its blue uplands, and its varied and varying lights and shadows; with its sparkling cataracts, its glittering streams, and its glassy lakes; with its flocks, its herds, and its wild animals, roaming from pasture to pasture, or bounding from cover to cover; with its flowers of every spot, and on every spray; its living inhabitants, from the eagle that dashes heavenward, defying the ardours of the sun, to the eel that leaves not the ooze at the bottom of the water, save to perform its curious migration to the sea; when the inspiring breath of the sweet south-west just puts the twigs and leaves into life, and the light summer-clouds, flinging their shadows, now here, now there, make the one view a thousand, ere the throbs of the renovated heart have counted the half of that number; when, in short, all nature is "beauty to the eye, music to the ear," essence to the smell, and life to the spirit;—there comes a new lustre on the eye, a young perception on all the senses; the arteries have more elasticity; the whole system, that was withering in art, waxes green in nature; and even near the brink of the grave man feels a triumph over death—a consciousness of immortality which no scepticism can shake, and no mortal misery cloud.

But this study is as important in fact as it is delightful in feeling. All that the human race can possess, or enjoy, or know, and the foundations or the proofs of all that they can believe, are contained in the existence, the appearances, and the laws (that is, the successions of appearances), of that vast and wonderful structure to which we give the name of Nature. It is at once the building and the book of "the living God:" the elder volume as compared with the book of Revelation, above all price as that is, and inestimable as are the blessings which it confers on man. That sacred volume is, as it were, only a special statute, given in the most beneficent mercy, but given only to one race, and for one purpose—a grand and paramount purpose, I grant, but still only one. It is "the law and the testimony" to man, for virtue in the present life, for hope in the life to come, and for enjoyment, for the only secure happiness and bliss, in both. But that which is written on the earth and the sea, and of which the lines extend farther into the sky than wing can cleave or imagination penetrate, is "the law and the testimony" to more races of beings than human arithmetic or even human fancy can number. Those which can be observed, with little trouble and no artificial aid, amount to many thousands of distinct tribes and races, each having appearances and characters by which it is distinguished from the others, and exhibiting at any one time, even in a small space, more individuals than could be counted. Who, for instance, would undertake to number the stalks of wheat in one field, the blades of grass that carpet one meadow, the plants on one heath, the fishes in one shoal, the sea birds that fly and scream round one rock, or the flies which, in one sunny hour after the rain has beaten to the earth or cast on the water all their ancestors, wanton over the surface of one pool? But these extents are but as so many mere points, compared with the whole surface of the earth; and the time during which they can be observed, even though it were extended to the whole life of the observer, is not as a moment to a year, compared with the duration of recorded time.

Vast as the number is, however, it is but a fragment, and a small and fleeting fragment, of created existence, in that manifestation of it to which we give the appellation of life. When we take hold of the microscope we find that there is another world, which, to the eye, is inscrutable; and that its inhabitants are probably more numerous, and certainly more wonderful in their structure, than the members of that world which we can see with the eye. That which to the eye appears but as a stain upon the wall, or as slime upon the rock, becomes, to the microscope, a grove or a forest of the most perfect vegetation, and as fully peopled as the groves and the forests with which larger spaces are clad. Nay, more, as no kind or portion of matter is absolutely solid, but has its ultimate atoms, to which we cannot philosophically assign any dimensions, separated by spaces which are, probably, as ample in proportion to those atoms as the distances of planets are to the masses of those bodies, it involves no absurdity to suppose that each of those atomic earths has its atomic inhabitants, as numerous, as varied, and as proportionate to it, as the tribes that inhabit our earth.

There may still be those who will be startled at such a doctrine as this; for it is the character of ignorance—which but too often assumes the name, and sometimes sits in the seat, of philosophy—to magnify its own attainments by denying that there is any knowledge except what it knows, or any existence with the mode of which it is not perfectly familiar. This self-sufficiency is the cause of very many errors, and one of the most grievous stumbling-blocks in the road to truth. Many have doubted the immortality of mind, because they knew nothing but matter; and many have denied the existence of God, because their own knowledge, which their vanity taught them to consider as amounting to all knowledge, reached only to a little of what man can do. Half the applications of modern discovery, which have made the world, and especially Britain, what they now are in human accommodation and comfort, would have been treated as vain dreams by the wise men of other times. If they had been told that the cotton wool, which a delicate-fingered female of India could spin in one day, could be carried twenty thousand miles, spun into better yarn, carried back again twenty thousand miles, and sold at half the price which she would demand, although her wages were only three halfpence per day, they would have been sceptical—nay, absolutely unbelieving. So also would they have been sceptical if they had been told that a bushel of coals could be made to perform the labour of twenty men for an entire day, or by the intervention of machinery (as in the case of striking a die), the labour of hundreds of men for the same period, they would have deemed their informant a most proper subject for the cell of the maniac. Yet these things are actually done, done largely, and done every day; and so much are they accounted mere matters of course, that nobody wonders at them, and very few speak of them. In treating of the productions of nature, or of any thing that depends upon their properties, to deny without proof is as unwise as to believe without proof. Nay, it is the greater error of the two, because more careful examination, or better directed experiment, will correct the error in the one case, but the denial shuts the door upon knowledge, and tends to render ignorance perpetual.

What has been stated is, still, only a small portion of that which the student of nature has to explore, or, at all events, to contemplate. When recourse is had to the telescope, the mighty in creation becomes as sublime as the minute is wonderful. That instrument discovers, revolving round the sun, twelve bodies, following similar courses, and apparently regulated by the same laws that regulate the earth; all of them of large dimensions, and four of them far larger than the earth. Eighteen moons, or satellites, have been discovered revolving round four of those bodies, and observing laws similar to those which regulate the one moon with which the earth is accompanied. Nearly one hundred other bodies have made their appearance at times, to which the name of comets has been given, and which, though the forms and positions of their paths be very different from those of the twelve first mentioned, and though some of them retire for ages so remote into space as to be beyond the power of the telescope, yet obey the same general laws, and may be considered as belonging to the same system with the others. Now, as the surface of the earth is but a little part, not the two-thousandth of the whole, and as we find that over the whole of the earth's surface the powers of nature are continually at work, it would be as absurd to suppose that the rest of the system is sterile and unprofitable, as it would be, in the few people of some bleak islet in the Polar Seas, to contend that there were no plants or animals on any spot of the earth but their own.

And with the solar system, vast as are the bodies of which it is made up, and wide as is the space over which they career in their revolutions, the works of the Creator are so far from being exhausted that the enumeration of them is barely begun. Of the fixed stars, which are beyond the limits that any instrument can measure, there are fifty thousand enumerated in the catalogues; a powerful telescope augments the number beyond all estimate (Dr. Herschel counted fifty thousand in one small patch); and, as the imagination cannot set bounds to the universe, the number seen by the best telescope must be but a small fraction of the whole. They must shine by native light, because the distance of the brightest, and, therefore, probably the nearest, exceeds immeasurably the greatest over which a borrowed light could come; and, as we have no reason to suppose that any two of these are nearer to each other than the nearest one is to our sun, it follows that the suns and systems are beyond the powers both of arithmetic and of imagination; and if that be the case, as there can be no doubt that it is, how vast must be the number of beings by which they are all peopled, and how far above all comprehension, above all praise, must be the attributes of HIM who, by one word, spoke them, and laws of their being, into existence!

is the ultimate conclusion which even minds not much accustomed to reason must draw from a mere glance at nature, if that glance be but comprehensive enough—if the mental eye has but its proper vision, and there is no fog of prejudice by which it is obscured. A perception, a proof that the Almighty is so great, coupled with the lesson of revealed religion—that the welfare of man, both in this world and the next, depends on obedience to the laws which the Almighty has promulgated for the guidance of man—is the most powerful incentive to virtue that can possibly be imagined, because it makes the very selfishness of man a cord to draw him in the way which is right, and thus converts that tendency of his nature which, under ignorance, is evil, wholly into good.

Were there no other advantage resulting from the study than the one now stated, that one would be ample reward for far more labour than a reasonable knowledge of the subject requires; but, like the kindred study of the sacred volume, not only a certain guide to the ultimate goal at which every good and wise man wishes to arrive, it is support and pleasure by the way. The very external appearances of the productions of nature, then, that are equally apparent to the learned and the ignorant, are highly attractive. The natural changes in those appearances that present themselves even to a very careless and superficial observer, are so curious that none can see them without feeling a desire to be informed of their causes. Their qualities are so numerous and so varied, and the uses to which they are applied are so indispensable, that without the application of some of them no human being could exist even for a single day; and without the application, the constant application, of many of them, no human being could exist in what we are in the habit of considering the very lowest state of civilized society.

But the use depends on the knowledge. There was plenty of sulphur, nitrate of potass, and charcoal in the world before the invention of gunpowder; but the people of those times never thought of so blending the three substances together, as that the ignition of them would batter down a wall, or tear a rock to pieces. The steam of water was just as powerful before the year 1700 as it is now; and yet nobody thought of making use of it to drive a carriage or a mill, or force a vessel on her way against wind and tide. Upon a very moderate calculation, the same steam now performs the work of two millions of men, and consumes not the food of a single individual. Therefore, in this single matter, the study of a few individuals has added to the means of enjoyment of the whole people more than thirty millions of pounds in the year. The soil of America or Australia was just as well fitted for the pasturage of flocks and herds, and the culture of the cereal grasses, before the discovery of those countries by Europeans, as it has been since; and yet, till Europeans took up their abode there, there was not a single sheep, ox, or corn-field in either of those wide regions.

There is another consideration which renders a knowledge of the properties of natural bodies of much more importance in a practical point of view. Every substance must be prepared before it is fit for use, and plants and animals may be both increased in number and improved in quality by culture. Neither the adaptation nor the culture can be successfully accomplished without a knowledge, not only of the natural qualities of that which is to be acted on, but of the means by which the desired change can be brought about. Hence the very humblest members of society, those who must labour every day and all day long, are not fit for the right and successful performance of their labour, if they do not know something of the nature of the substances on which they are employed, and the means by which the changes that they have to produce in those substances can be best and most easily brought about. A shepherd, for instance, would be but a bungler, if he knew not something about what promoted the health and growth of his flock; when they would be best on the dry part of the sheep-walk and when on the moist; also, what plants required to be grubbed up, as being injurious to their health, and what encouraged, as having a contrary tendency. It is the same with all who are engaged in any kind of labour, be that labour what it may; and in proportion as the individual rises in the scale of society, and, instead of labouring as an individual, superintends the labour of others. Indeed, taking the single view of practical utility,—of application to the means by which the necessaries, the comforts, and the elegancies of life are found,—the only man to whom the knowledge of nature is of no use, is the man (if such there be to whom the name will apply) who does and who wishes to do nothing that is useful.

There are, however, nobler motives in the study than the mere pecuniary usefulness, although that usefulness ought not to be despised, and though it must always be in proportion to the others. Ignorance of the appearance of natural substances is the source of many evils and inconveniences. The noxious is often, on that account, taken in place of the wholesome; and that which is perfectly harmless invested with the attributes of something deadly. We often hear of sickness and death, from gathering and eating various species of water-parsnip *(sium)*, and especially water-hemlock *(cicuta virosa)*, instead of water-cress *(nasturtium officinale)*, as well as by mistaking some of the poisonous fungi for the esculent mushrooms. On the other hand, many persons make themselves miserable in reality, and ridiculous to those who are better informed, by attributing mortal qualities to toads, spiders, and other creatures, that cannot by possibility do harm to man; and accusing newts of creeping into the throats of persons asleep, and earwigs for taking up their abode in the ear,—situations which those creatures would be very careful to avoid.

This ignorance not only leads to such mistakes as those of which one or two have been mentioned, but to ridiculous beliefs in the virtues and the baneful effects of substances, which, if they are not physically so fatal as some of these, have far more injurious effects upon the mind, and lay people open to countless quackeries and cheats at the hands of the unprincipled and designing. The history of the reputed medicinal qualities of very many substances is little else than a chapter of the annals of imposture, and the charms and counter-charms that were once so very largely imputed to substances were wholly of that character. The latter have nearly disappeared with the art of which they were the auxiliaries; but the former still remain to a considerable extent, even in quarters where they would not be suspected. The cause is obvious. The belief in supernatural malignity was a mere dream of the imagination; and, when the minds of people were roused out of the sleep that produced that dream, the counter-dream vanished. Disease, on the other hand, is a reality, and a reality from which all are anxious to escape; and it at the same time enfeebles the mind, and makes absurdities be resorted to, in quest of cure, which the patient would scout if in health, and if they had reference to any other matter. The mischief which is done in this way would not easily be credited by those who have not closely studied the matter; and there is no way of combating that mischief successfully, but by a more accurate and more generally extended knowledge of the productions of nature.

But of the immediate advantages of the cultivation of this kind of knowledge, the most valuable remains still to be mentioned,—the elevation of mind—the pleasure which cannot be taken away, that results immediately from the study, and thus brings a reward to the student at every step of his progress. There is no surer way of keeping the mind awake and in tone, than by having a subject for thought and reflection that shall appear fresh and new every day, and with which man shall find something analogous wherever he goes. Enjoyment is the grand object of life, and thought is the chief measure of its duration. As determined by the revolutions of the earth, man cannot expect to exceed, upon the average, his "threescore and ten years;" but, in that period, one man may contrive to live ten times as long as another, simply by knowing ten times as much. And, to the man who has made himself familiar with nature, there is not a spot of earth or a moment of time but which will bring its employment. Every portion of earth that is turned up, every wave that rolls to the shore, every plant that grows, and every animal that flies, or walks, or crawls, or swims, or which, like an oyster, is cemented to the same place for life, will be to him a leaf of the book of knowledge (of a book far more instructive and delightful than any that can be written by man. The book that man writes, even though—which was never altogether the case, and is egregiously not the case in these days) it were the production of one who had carefully studied and well understood the subject, is but a copy, and, as such, liable to all the errors and mistakes of the copyist; so that the mere reader—the student of books, lies exposed to two sources of error—the blunders that he may make himself, and those that are made for him by his author. The probability is that that author, in all that is of any value in his book, may also be a copyist—a mere tagger together of "a thousand and one" scraps, loosened from their original connexion, and therefore entitled to no higher epithet than the debris and rubbish of that which, in its original state, may have been knowledge; consequently there is no faith to be placed in the *mélange* until the reader has reapplied all the scraps to the places whence they were taken.

The grand object is to enable those who have much leisure to banish listlessness and ennui, by a perpetual source of occupation and enjoyment, and those who have little leisure to make the most of it. That is not to be done by having recourse to laboured descriptions and costly delineations of things that the student has never seen, and of which all the circumstances of a single subject could not be explained in less than the whole compass of a volume. The thing wanted, the source of happiness, the foundation of utility, consists in people seeing and knowing that which is around them, and which they may examine any day or every day, without cost and without trouble. Books have their value, and a high value it is; but in acquiring that knowledge of nature which is either to be useful or pleasant, actual observation will do more in one hour than reading can do in a month. Another thing: the less ostentatious that any one is of the knowledge which he possesses, the more good it is sure to do him; because the time that the boaster wastes in proclaiming to the world may be employed in the acquisition of more knowledge by him who boasts not. But that which a man acquires by his own observation is such as may be acquired by any body —has none of the pride of learning about it; and, therefore, the possessor boasts not of it, but goes on quietly adding more.

These remarks do not of course apply to those who study nature as a profession, but merely to those who do it for their own information and enjoyment. The professor, whatever be his profession, must *profess*—must have some blandishment to attract his customers, upon the same principle that the vender of wares paints and gilds his shop. Every body knows that those decorations do not improve the quality of the wares—nay, that the wares must cost more because of the decorations; but still they are found necessary, as people will not resort to the shop without them: the user, however, needs no sign and no gilding. And it is the same with knowledge as with any thing else: he who wishes to sell it must show it off; he who uses it has no such necessity. Still the objects in nature are so many, and they have attracted the attention of the curious and the active so long, that there must be some preparation before any one can know how to begin, and some knowledge of what has been done by others, in order that time may not be wasted in searching for that which is already known, and that the knowledge which the individual derives from observation may be in accordance with that which has been observed by others. When a man walks out to observe, or rather that he may be able to observe, and think, and learn, every time that he walks out he should be able to see and judge of not the mere individual object, but of its circumstances and accompaniments, and the connexions that subsist between them. If, for instance, the native plants of the hill differ from those of the valley, he should be able to say why that should be the case; or if a plant in one part of a field differ in its growth or any other of its changeable characters from a plant of the same species in another part of the field, he should be able to point out what there is in the soil or the exposure to produce the difference. The existence, at all, of any production of nature, in a particular place and at a particular time, must be owing to some circumstance or combination of circumstances; and that it is found under any one modification of appearance rather than another must also be owing to circumstances. Now, it is the knowledge of these circumstances which enables us to unite the single objects into a system, and to look upon nature in all its variety as one great whole, all the parts of which harmonise, and are mutually and reciprocally useful and necessary to each other; and thence we are enabled to bring together the same circumstances from which we have invariably seen the same result to follow in nature, and thus we obtain the result that we wish for in art.

But though in the use and the enjoyment of natural knowledge it is necessary to take the productions of nature in their combinations and with their associations, the mere elements cannot be acquired in that way. There must be in this, as in every species of knowledge, a division into parts — an alphabet, as it were; and it is only after all the parts of that are well known that the knowledge of them can be put together, and nature contemplated with pleasure and profit, in those groups and masses which present themselves to the observer.

The great division of the empire of nature is usually made into three kingdoms—the mineral, the vegetable, and the animal; well defined and boldly contrasted with each other in some parts, like the different colours in the rainbow, but, like these, so blended on their confines that it is not easy to distinguish the one from the other. The popular distinction is, that all the members of the vegetable kingdom have *life*, and may be in the state of *living* or *dead;* and that the members of the mineral kingdom never have life, and, consequently, are always dead. Life is, however, so vague an expression that, unless when it is applied to some particular being, the mode of whose life is known, its meaning cannot be defined. It does not consist in motion from one place to another; for almost all plants, and many animals, are fixed to the same spot for life. It does not consist in the power of assuming some definite form; for all substances that can be crystallised (and probably there is no substance which may not in some state—though that be always, as compared with vegetables and animals, a dead state)—undergo the process of crystallization. Nothing is more limpid than water when in the fluid state—the keenest eye, or the most powerful microscope, can detect no parts in it; and yet let there be but cold enough, and that water forms crystals of snow, hail, or ice, which, whether they be in white flakes like snow, white masses like hail, or colourless as the icy crust of pure and tranquil water—have the original crystal, and the mode of aggregation, always the same. The whiteness and the inferior weight of snow, as compared with transparent ice, arise from the water being agitated, or the particles separated from each other, at the time of crystallizing; and there is, perhaps, no substance of which the aggregation of the smaller crystals may not be modified in the same manner—though in each the primary crystal is as characteristic of the particular substance as any other of its qualities. Increase of size, or growth as it is called, is not a characteristic of life, because in some circumstances stones, or accumulations of mineral matter, also increase in size; nay, even the assimilation of other matter to the same kind with the body of the individual is not a certain criterion of life: the diamond-miners in India (at Pannah in particular, where the same *caste*, or tribe of men, have been employed for centuries) declare that they find as many diamonds in the ground which, after being carefully searched, has lain fifteen or sixteen years, as in that which is dug for the first time; and it has been stated that quartz crystals may be obtained by watering, for a sufficient length of time, a portion of the rock on which they are usually found, even though that rock should be removed to a situation very different.

Those formations of crystals that can be effected by the operation of chemistry, where both the powers that are brought to act, and the resistances that retain the constituent parts of bodies, are limited to human skill and human strength—are, yet, enough to show what may be done with more ample knowledge and more powerful apparatus. The qualities which have been given to substances by their Maker—are, in their own nature, immutable; and there can be no question that the carbon which exists in common pit-coal, in wood, in a living plant, or a living animal, is just as much endowed with the faculty of crystallization, as that which blazes on the aigrette of an Omrah, or sparkles to the movements of a princess. The combinations in which it is found are the only hindrances. Hitherto art has not been able to trace them, and probably art never will be able; but no inference can be drawn from that against what may be done by those energies which, we know, could in a moment shiver the globe into dust, or turn all the masses in the solar system into trackless and viewless air.

These circumstances are mentioned as a caution to the ordinary reader, for whom these pages are chiefly intended, not to consider the distinctions of kingdoms, classes, genera, or any others that men may, for their real or supposed convenience, as distinctions made by or existing in nature. There we find nothing but species, or, perhaps, rather individuals, often changed by circumstances into varieties, and in all probability depending upon circumstances for their own existence; just as we find that it depends on the circumstance of less or more heat whether water shall be solid, liquid, or in a

ur; or as it depends upon soil, situation,
whether an oak shall be stunted like
t, thick, and spreading, or rising erect,
ht hole many feet in height.

he most general, and therefore the most
distinction that we have between the
ctions of nature and those that have
fe, is *organization;* that is, a combina-
ngement of parts or organs, all different
appearance, and adapted to the per-
different functions. Here again, how-
ome perplexed on the confines. The
ing, though there is a unity and even
of parts about it, is not always, as a
ure, one. Setting aside the production
seeds, and by roots (as in the potato and
plants), a single tree of some species
lly furnish a whole grove in cuttings,
uttings be planted in the proper manner
he proper time; and so obedient are they
some cases (such as that of the common
), the cutting may have either end placed in
round, or be laid in it lengthways, provided
a bud upon it. There are animals, too, and
aving the power of locomotion, in which
part of the body, instead of dying when
an produce all the other parts.

are the singular varieties which we meet
nong the productions of nature, and yet
are some single laws that run through them
As matter they are all subject to the law
ravitation; and when the more partial laws

that determine their individual organizations are suspended or destroyed they all obey that. The other laws, however, when in operation, are sufficient to overcome that, even when they act in a very small portion of matter; as the least portion of water freezing in a chink can burst a rock, or the most apparently feeble plant raise itself in the air. Indeed, though we are in the habit of associating power with magnitude, magnitude seems so far from being the measure of those powers by which nature works that it is absolutely a clog upon them. The spring of the tiger is nothing, comparing the size of the two animals, to the leap of the flea: an ant is stronger in comparison than a lion, and its motion over the clods is much the same, compared with its bulk, as if a man were to run over a city, taking the highest houses, and even the towers and steeples, in his way. The whole is wonderful and delightful, and all is so inviting that there is some difficulty in knowing where to begin.

CHAPTER II.

INDUCEMENTS TO THE STUDY OF PLANTS.

PERHAPS the portion of nature the study of which is the most easy for beginners, the most accessible at all times and in most places, the most pleasing in itself, certainly not the least conducive to practical usefulness, and therefore the one most likely to gratify all tastes, and find students in every class of society, is the vegetable kingdom. We have not to dig in the earth for the vegetable as we have for minerals; neither have we to chase, catch, or kill it before we can examine it, as is the case with animals. It stands in the light of the sun and the pure air of heaven, so that the very examination of it in its native state is an exercise conducive to health. At the same time there is nothing about any vegetable which even the most fastidious can by possibility consider as indelicate. In a menagerie, be the animals ever so curious, be they brought from every latitude and every longitude, and kept with ever so much care to safety and cleanliness, there always is something offensive about them. Such a collection is nothing without its lions, its tigers, its bears, its baboons, and its serpents; and besides the associations of rending living flesh, and lapping warm blood, and crushing to death, and poisoning, that are inseparable from the sight of such animals, their roaring, and growling, and chattering, and hissing, are any thing but music to the ear, while they are very far from being essence to the smell, even of persons that are not very delicate. It is not so with collections of vegetables: from the best-stored botanical garden, in which the plants of every land are collected, down to even a heath with its wild flowers, a meadow, green despite the rigour of winter—nay, even to a marsh, with its sedges and its water-lilies, all is pleasant.

Whether, indeed, the object be delight, or instruction, or never-exhausted suggestions of practical application, the vegetable kingdom holds a very forward, if not the very foremost, place. It is free, too, from some sources of error to which the study of animals is exposed. The organs of perception in animals, and the general structure of many of them, are very analogous to those of man. Some of their perceptions far exceed his in intensity, and some of them exceed him in strength and duration. Now, though there is nothing in any or in all of these circumstances that brings man into kindred with the other animals, yet, as their organs of sensation, and their sensations themselves, are called by the same names, there is some danger that by such studies the unreflecting may lose part of the feeling of their own immortality. A more extended knowledge of the animal tribes fails not, indeed, to correct this tendency, because it is then found that the races which have the least resemblance to man—those in which no allocuted central brain, and no organs of sensation are visible—are just as perfect in their kind, and as admirably adapted to the situations in which they are found, as those that resemble man the most. But in the study of vegetables, whether that study be narrow or extended, there is nothing calculated, in the least, to stir a suspicion of the kind that has been named.

When the inspired writer sets forth the grounds upon which the title of King Solomon to pre-eminent wisdom was founded, he places the knowledge of plants foremost and most conspicuous among natural objects. "And he spake of trees, from the cedar-tree that is in Lebanon, even to the hyssop (*mucor?*) that springeth out of the wall." And who is there that has seen trees—that has looked upon such a prospect as may be obtained from any hill-side in England, and can refrain from speaking of them—from wishing to know all that can be known about them? Passing by, in the meantime, the consideration that a tree is a house, furniture, and fuel; that it may be made clothing, and even bread; that it forms part of almost every implement and every machine by which the genius of man has taught him to lighten the labour of his hand; setting aside the considerations that we lean upon it as a staff—that we ride in it as a carriage—that we cross the river on it as a bridge—and that by means of it, as a ship, we traverse the widest seas, and circumnavigate the globe itself: —passing by these and many other utilities, in all their modifications, there is that in a tree, considered as an individual work of the Creator, which may well excite our attention, and most amply reward our study.

Other productions of nature are soon gone: the insect sports for its hour, and then it is no more; the bird sings for its season, and then wings its way to other lands; one crop annually succeeds another; domestic animals wax old and must be replaced; the grey-haired man talks of those of the days of his prime as of beings of a period almost forgotten. But the man who recals these, as otherwise lost to memory, may be sitting the while under the same oak, or chestnut, or hawthorn, or yew, beneath which his grandsire sported in infancy—and to reach the magpie's nest in the bark of which was one of the earliest stimuli to his own ambition.

A tree of this description is, in short, a sort of perennial calendar to the village, from the time that its size first renders it an object of general notice; and, after it has outlived the rise and fall of successive generations, it becomes the most ancient of living calendars. It registers events, and it registers seasons. Children play under it; under it faiths are plighted, farewells taken, and friendships renewed; and when friends are apart the tree is a sort of artificial memory to them. If the spring is early, it is borne in mind as the one in which the great tree budded so soon; if it is late, the tree is a record equally faithful. So many are the recollections that when one who has spent boyhood in a village where there was such a tree, and, returning after a life spent in other parts, finds the tree gone, nothing that is not human can cause so much regret.

So also the tree which the man plants is among the chief of its inanimate favourites, and it is always the more dear to him the more that it is the one planting. The sentiment here is far from a bad one. It is to the duration of a tree that our fondness clings. An annual plant is soon gone, and we forget it in our attention to the plant of the next season; but the tree "summers and winters" with us, and is probably one of the most expressive of simple monitors, in leading us to think beyond the passing hour and its fleeting appearances. To some it may seem that these charms of the tree that we have mentioned are but trifles; but of such trifles the happiness of man is made up; and, when we analyze those matters which are usually styled great, we always find that they are ultimately resolvable into elements equally trifling.

The tree "summers and winters" with us, and is at once the key and calendar of the year; and, rooted as it is to the spot, it has many lessons to teach us. It comes into leaf in the spring; is green and spreading, flowering and fruiting, during the summer; the leaves get sear and yellow in the autumn; the connexion between their footstalks and the twigs lessens, and they separate in such a manner as that the places which they leave are not wounds, but healed cicatrices the very moment that they drop. This putting off of its summer garniture is no disease, no casualty or misfortune, so to speak, to the tree. On the contrary it is a protecting measure—a most wise provision—without which the life of the tree would be periled, or its boughs rent one from another. Any one who has noticed the havoc which a single night, even a single hour, of frost can make upon trees when they are in action, must be aware that if that action were to continue through the winter we should have no aged tree in the forests. But nature provides against such a catastrophe: the leaves expand, and the shoots lengthen, to the measure of their year's growth—the latter bearing their rudiments of buds according to the habit of the tree; sometimes on the end of the shoot, and there only, as in the pine; sometimes just under the leaf, and sometimes so far covered by the *petiole*, or footstalk of the leaf, that the bud is hardly seen till the leaf drop off. Before the leaves begin to decay the wood begins to ripen; and, by the time that they fall off, the twig, which in the early part of the season was succulent and juicy, becomes firm and elastic, with ligneous fibres. The buds, too, are cased in armour—in plates, and scales, and folds, covered with a resinous matter which the temperature cannot easily affect, and the mechanical structure of which is such that it cannot be easily opened, except by an effort from within. The bud of the common beech is a very beautiful instance, but it may be seen in most trees. Even if the tree is an evergreen, its winter economy is nearly the same. Though those who have not attended to the facts are apt to confound them, an evergreen tree and an ever-growing tree are far from being the same. During the winter months vegetation is as still in the leaves of the ever-green as in the twigs of the deciduous tree; and when buds are prepared and brought to a state of forwardness, as is the case in the pine, they are as well protected as in those trees that shed their leaves. Although, therefore, the evergreen does not drop its leaves till the winter be over, and the vegetable action of the tree be considerably advanced in the spring, yet the winter is as much a season of rest to the pine or the yew, as it is to the mulberry, which puts not forth a leaf till the summer be fully come, and drops them all in the earliest part of the autumn. Now, as the action of the tree in any one country, in England, for instance, depends upon the seasons—is called forth by a certain degree of heat, and rendered quiescent by a certain degree of cold—it follows that, by observing the seasonal aspects of the trees in one country, and knowing the climates of other countries, the habits of trees there may be determined. The tree has been taken as one of the most striking instances, but the very same principle applies to all vegetables; and thus it is easy to extend one important part of the knowledge of them to every region of the globe.

It is not by heat alone, but by a due measure of heat and humidity, that the vegetables are called into the most powerful action. If the heat be in excess, the tree languishes, and the more fleeting productions of the field are burnt up; and if the humidity be in excess, the evaporation and consequent cold prevent the ripening both of the fruit and the wood. In every part of vegetation we find the action very nicely adapted to the circumstances; and though we know of nothing that can, under any circumstances, produce the germ, but a parent plant, or the immediate will of that Being who originally willed that they all should exist, yet, in vegetables, all the rest is owing to the circumstances in which that germ is placed. Here we see one of the great principles of Nature's working, and the strong inducement which Nature holds out to man to study and improve. Every species is *of itself* as it were; we cannot connect it with any thing else. We may know the very best situation, soil, and climate, for the growth of oak timber, but without the acorn we cannot have a single oak. We have nothing but lineal descent for that; and whether, in imagination, we trace that descent through hundreds or through millions of generations, the acorn is as necessary to the existence of the first individual as of the last; so that, pursue it as we will, there is no beginning but the work of a Creator. In every species that has come under observation the case is the same; and, therefore, the *creation* of every tree, and every herb bearing seed *after his kind*, is one of the very first truths demonstrated by the study of plants.

though no combination of natural circumstances, and no cultivation by man, can produce a new species, or change one species to another, the unalterable law extends only to the specific character, and all else may be varied without end. The oak which stands on the bleak height, exposed to every wind, is a mere shrub compared with that which grows in a rich field or a fertile dell; and the wheat on a rich loam is a forest of reeds, in comparison with the last upland ridge on the verge of the moor. So obedient, indeed, are the vegetable tribes to the hand of the cultivator, that, with the single exception of changing the species, man may make them almost what he pleases. Hence, of all those that have been cultivated from before the records of authentic history, no man can, with any thing like certainty, tell the native region. Who can tell the native region of wheat, or point out, growing wild, the plant out of which it was cultivated? And yet it must have been cultivated out of some specific wild plant; for man, in the very acmè of his agricultural skill, can no more make a stalk of wheat than he can create a world; and no more change it into any other species of grain than he can speak the globe out of existence. The potato is a plant comparatively new to culture; and yet the parent is not ascertained beyond question, or, if it be, that obedience to culture which has enabled the art of man to bring so many varieties, seasonal as well as others, of one of the most desirable and wholesome articles of food, out of an original which has not many apparent good qualities to recommend it, is truly wonderful.

If the plant adapts itself thus easily to man's culture, man, in that culture, does nothing more than give the circumstances under which, if they were to exist naturally in their connexion, nature would produce the same result without his interference. Wherever he can bud or graft, Nature, under proper circumstances, could inosculate; and when, by means of an improved soil, he improves the variety, Nature, under circumstances exactly similar, would do exactly the same. The very fact, that there is no wild plant resembling those that man has for a long time cultivated, is a proof of this perfect adaptation in the vegetable tribes to circumstances. There is no combination of circumstances in nature answering to those of a well-cultivated field. Nature has no means of under-draining the soil, or reducing it to a mould, as is done by the plough, of tempering it with manures and composts, and of preventing the strength of it from being exhausted by weeds. She is equally bountiful to all the races that she has made; there is no weed in her field; and thus, in every place where there are the means of vegetable life, all the species that are adapted to the circumstances of that place come in for their share, until some one, which is more congenial, of stronger growth, or longer duration, shoots up, overtops and chokes the others. As, for instance, the side of a mountain shows nothing but heath, and the mosses and lichens which are the usual concomitants of that upland shrub. Plant the same with pine or with larch, and watch the event.

For several seasons the heath waxes more vigorous, and thickens till the mosses and lichens are exterminated. But, as the heath grows by inches, the trees grow by feet; their lateral branches meet and exclude the air, till that which was at first shelter to the heath becomes suffocation in the end. The spines or leaves of the trees fall annually, and are decomposed along with the decomposing heath; the mass of vegetable matter in a state of decay is the very nursery of fungi; the light and generally invisible germs of them are every where; secure in their littleness (which is a very general security to the embryos of life) they may resist the weather for years—for ages, until they meet with the combination of circumstances which is favourable to their development, and then they grow abundantly in places where they were not before found; so much so, that those who are ignorant of their economy suppose that they spring up by equivocal generation. As the trees advance, their upper branches gradually shut out the under ones from the light, and these decay in turn, till, while the trees form a canopy over head, the air plays between the now comparatively bare trunks below. Grasses then make their appearance; but, as the sun lights not on the ground, there is comparatively little evaporation; the fall of leaves and of twigs causes a succession of the fungi; their decomposition prevents the moisture from escaping into the surface; and those circumstances favour the production of the green mosses. If the trees themselves are allowed to stand, their seasons, many though they may be, are at length numbered. The greenness gradually creeps to the extremities of the remotest twigs, the annual additions to which become of imperceptible length. The greenness disappears, the bark falls off, and the white trunk and branches stand a lifeless skeleton. It is the polity of nature that no portion of organic matter shall remain idle; and thus, as soon as a lifeless tree begins to cumber the ground, the axe of Nature is laid to its root. The pine and the larch, the trees alluded to, do not send up saplings from the root, as is the case with many other trees. Thus the damp, with its fungi, soon rot them at the surface of the ground; they fall, and each forms a sort of dam for retaining moisture. Fungi are the first crop, and they continue till the trees are at last hidden in an accumulation of moss. That continues to grow at the top and decay at the bottom, often till it reaches the height of many feet, and always (in cold climates) till it has formed such a slope as that the water will not stagnate on its surface. That then dries, and we have heath again. Such is the rotation of one set of vegetables upon one description of soil and climate; and there are natural rotations for all soils and climates that are capable of producing vegetables—varying in the details, but in principle the same.

Plants are much more obedient to circumstances than animals, at least they appear to be so, and the reason is a very obvious one: as the seasons change, the animal can change its place.

If a bird, it can migrate as the seasons change; and even quadrupeds change their ranges as their habits with the season. Many quadrupeds and reptiles *hybernate*, or pass the inclement months in a state of inactivity; and those that do not, and yet remain in cold districts, have their clothing adapted to the season. But, whatever may be their adaptation, they all have the power of going into shelter; while plants, rooted in the soil, must abide the weather as it comes, and have in themselves their sole means of defence under its changes, and from its inclemency.

This circumstance gives to the study of plants a double pleasure and a double utility. The names of plants, and their individual appearances, may be known as separate matters, and without the aid of any other knowledge; but from these not a single useful conclusion can be drawn. If we would have an answer to so simple a question as, Why one species of plant is found only on the meadow, and another only in the marsh; or why the same species is stunted in one situation and vigorous in another?—we should seek for the answer in vain, from the name and the external appearance. Even for that simple matter we must attend to other departments of natural history—must look to the situation, and see what there is in that which renders it favourable or unfavourable to one plant rather than to another. In like manner, when we find that one season is more favourable to any species of vegetation than another season, we are led to examine the circumstances; and thus places and seasons, and the productions of those places and seasons, mutually throw light upon each other.

And it is not difficult to generalize those particular observations; and according as we find, in a country so varied in soil and seasons as England, the modifications of the vegetable tribes that attach themselves to these, to infer what must be the influence of all the varieties of climate and season that diversify the world: and though the knowledge of the climate and seasons, and their modifications, does not, of course, give us any information as to the species of plants that may be found at any place, yet it lets us know what the general habits of those species must be; and, as warmth and humidity are the circumstances that call the principles of vegetable life into action, we are, by the knowledge of these, and the observed habits of plants, furnished with a general system, which guides us safely in collecting and arranging the details.

Setting aside the specific nature and appearance of plants, which, as they depend on the individual plants themselves, can be found only by observation, we have the following general circumstances in the economy of the globe, as guides in our inquiry—not that any of them is to be taken as, singly and literally, producing that effect which from calculation we would infer—because they modify each other, and are modified by the nature of the soil, and other local circumstances which cannot be generalized; but still they have an effect, though not one that can be accurately stated in numbers.

First, difference of latitude, as affecting the average temperature—the general heat and cold of the year, and also as regulating the seasonal distribution of that temperature.

Secondly, elevation above the mean level of the earth's surface, as modifying the temperature in the same latitude.

Thirdly, humidity, or the quantity of rain that falls, and the distribution of that rain—whether it be collected into rainy seasons, or more distributed over the whole year.

These are the most general circumstances, and without some knowledge of them the nature of plants cannot be very successfully studied, nor can those general views be obtained which connect the study of plants with that of other productions and phenomena of nature; and, it may be added, that, without the knowledge of these, those plants which are useful to man cannot, at any one place, be successfully and profitably cultivated. The husbandman or the gardener is, therefore, in all cases, and in many cases without knowing it, a natural philosopher; and though, in a district which has been long under culture, the knowledge which is essential to that culture is oral, and appears to be almost intuitive, it is not, on that account, the less scientific. There are some other circumstances that have very considerable effects upon plants—such as the position of the surface of the ground, its distance from the sea, and the set or direction of the most prevailing winds; but these affect vegetation chiefly as they influence the temperature and humidity. Most of them are also local and not general; and thus they refer rather to the distribution of particular races of plants than to the general activity of vegetation, or to its continuance through a greater or smaller portion of the year. The few observations that follow shall, therefore, be confined to the three circumstances that have been enumerated.

1. *Latitude.*—The mean annual heat, as varying with the latitude, was, by the older writers, considered as synonymous with *climate*, though that term has now come to have a much more extended signification, and to comprehend not only all those circumstances that affect the growth of vegetables, but those also that affect the health of animals, and especially of man. To prevent reference to other books, it may be mentioned that, at the equator, the sun shines for twelve hours every day; and that, twice in the year, on days half a year distant from each other, the sun is vertical, or directly over head at mid-day. At the equator, therefore, the whole annual influence of the sun is greater than at any other latitude, and it is more uniformly distributed throughout the year. At those times when the temperature there is the least, the sun still rises due east, and sets due west, and the deviation from the vertical point at mid-day is less than 23½°. The seasonal variation of temperature is, consequently, very trifling; and, consequently, were the degree of humidity the same, the causes of vegetable

action, and that action itself, might be considered as nearly uniform all the year round. At the equator, the mean annual temperature is about 85° of the common thermometer, a temperature sufficiently high for maturing any known vegetable.

As the latitude increases, the rays of the sun fall more obliquely on the surface, and the temperature is lower. The change at first is very slow, being only about 1° for the first 500 miles northward and southward, so that there is a zone or girdle in the tropical parts of the globe, 1000 miles in breadth, which, as depending on latitude, has little difference of annual temperature. At the extremities of this zone the difference of seasons would be but begun; but it is not perceived, as the changes of seasons there do not depend on the immediate action of the sun.

After the latitude has become considerable, the diminution of temperature, and the difference of the seasons, become much greater; and at the poles the average annual temperature is estimated at 32°, or just the point at which water freezes. In so far as vegetable action depends upon water, there can, therefore, on the average of the year, be no such action at the poles; and thus we have a regular gradation of that action, from the maximum temperature of 85°, down to 32°, at which it ceases altogether.

But, as the average temperature becomes less and less, the accumulation of that temperature into a summer, and the withdrawal of it in a winter, become more and more marked. About the north end of the Gulf of Bothnia, in Sweden, is probably the highest latitude where, at the average temperature (about 40°), grain of any kind would sprout and vegetate; and about the middle of France is the highest latitude at which (temperature 57°) an average crop would ripen. But, at the former place, the midsummer sun produces its effect the whole twenty-four hours, and at the latter at least sixteen of them. Thus, during the short summer in Sweden, vegetation is called into action by the almost continual presence of the sun; and at the middle of France we have arrived almost at the southern limit, where land, on the mean level of the earth, becomes too dry and hot for wheat, unless when counteracted by local circumstances. Thus the seasonal distribution carries the power of vegetation, alternately, much farther into each hemisphere than it otherwise would reach, and gives scope to a vast number of seasonal plants, the hybernation of which increases in duration, in proportion as they are farther from the equator. This change is slow towards the equator, and it gradually augments as the poles are approached; but still, within short distances, it is hardly any where perceptible; and that, joined to the influence of difference of elevation, gives a considerable range in latitude to most plants.

2. *Elevation.*—The change which elevation produces on temperature is a diminution as well as that produced by latitude, but it has no seasonal modifications; and, therefore, the plants that are found at different heights, on a mountain-ridge, are

not the same in their habits, and, consequently, cannot be supposed to be the same in species, as those which clothe latitudes having the same range of average temperature as the different elevations of the mountain. There are mountain-ridges—the Andes in Peru, for instance—which, situated at the equator, and having a considerable portion of their peaks clad with never-thawing snow, present upon their slopes, in succession, all the average temperatures of climates, from the equator to the pole. But in these, we have not, as the average temperature diminishes, the portion that remains accumulated into a summer, short but constant while it lasts, in proportion as its whole quantity is diminished. Hence we have not, upon their upper classes, a vegetation which is active for three or four months of the year, and quiescent during the remaining and longer part. We have plants of low stature, and so hardy constitution that they must bear the alternations of sunshine and frost, for almost every twenty-four hours in the year. Consequently, though the plant of the tropical mountain, and that of the polar country, may be of the same family, or even of the same genus, their habits are so different that an immediate interchange would probably be fatal to them both.

Many plants, of which the potato and the dahlia are striking instances, have been greatly improved in appearance and quality by transportation to more temperate climates than those of which they are natives. Both of these are originally from the same country, Central America, and both are probably from the same elevation, the plain, or table-land of Mexico, about 6000 feet above the level of the sea. They must both be so low down as that no frost can reach them during the season of their growth; because, throughout the whole of that season, the frost of one night is sufficient to destroy them, and the temperature of freezing is sufficient to destroy their tubers in winter. The whole habits of both plants show that the temperature where they are natives can never be, even at those seasons when the stems and leaves have died down, and the vegetable life has retired into the tuber, so low as freezing for any length of time; and the improvements that both have undergone by cultivation, in the temperate climate of Europe, would lead us to conclude that their native summer is not so warm as that of the countries to which they have been transplanted. Something is, no doubt, due to the stimulus of contrast —the more perfect repose of the colder winter, and the awakening of the more genial summer; and much more is due to the roots being taken up, and kept comparatively dry during the winter months; for, when left to "plant themselves," they soon degenerate, or are soaked and rotted by the cold rains of winter.

These examples point out the advantage that may be obtained by the transplanting of vegetables from one climate to another; and it is not a little remarkable that that can be done to the greatest advantage in those changes which take place to a higher latitude. Natives of the colder climates are not only not improved, but are kept alive with great difficulty, when brought to regions that are warmer; and that takes place even though they are planted in their native mould, or in a compost approaching as near to it as the art of the cultivator can reach. Much remains to be learned before this important part of the natural history of plants can become perfect science; but, from the facts that have been stated, it seems that, if the humidity bears the same proportion to the temperature, the plant thrives the better, and comes to the more vigorous maturity, the more nearly that it is exposed to the continued influence of light during all the time that it is in a state of activity. The circumstances under which all plants suffer the most are rapid changes of temperature—warm days and cold nights; and it follows, by necessary consequence, that the more that such changes extend over the year, the harder must it fare with the vegetable tribes.

3. *Humidity.*—Though it may be stated, as a general fact, that the quantity of humidity which falls upon the ground and the plants covering the ground, in the state of rain (or snow), or which forms upon them in the state of dew, is a maximum, or the greatest possible, at the equator, and diminishes as the latitude increases; yet the absolute quantity, at any one place, and the seasonal distribution of that quantity, depend on so many local causes, that the determination of them is almost entirely matter of observation. The directions of the winds, with the nature of the surfaces over

which those winds blow, elevation above the mean level of the earth, the form of the surface, the nature of the soil, the kind and quantity of vegetables upon the surface, and the vicinity or distance of bodies of water, whether of the sea, of lakes, of rivers, or of marshes, all have an effect on the quantity of humidity. Very many circumstances, too, affect its seasonal distribution. A region may have causes of rain only from without, or it may have them from within also. Rain may, in general, be said to result from the mixture of strata or currents of air, having different temperatures. The power which air has of retaining moisture in a state of invisible vapour increases with increase of temperature, but it does so more rapidly. Therefore, when two strata, having different temperatures, mix, and the mixture assumes the mean temperature, the capacity of the whole for moisture becomes less; and if both strata were previously charged with moisture to their full extent, there must be in the mixture an excess which that mixture cannot retain. Consequently it must fall to the ground in rain, unless, as we often see in a summer-cloud in dry weather, it be dissolved by the lower strata of the atmosphere before it can reach the earth. These lower strata are always the warmer, and hence, volume for volume, they can retain much more humidity than the strata higher up. So much is that the case, that there is hardly ever a shower, and certainly never a temporary shower, in weather of moderate [illegible], of which a considerable portion is not taken up by evaporation by the air nearest the ground. So much is that the case that, on an average of observations carefully and constantly made, it has been found that, for every *five* inches that fell at the height of 20 feet, there fell *eight* inches at the height of 600 feet, though the distance of the two places was not above a mile; and, therefore, it may be presumed that the same shower would be *over* both, with nearly the same intensity. It is true that the place where the five inches fell was peculiarly warm, and sheltered from the bleakest winds that blow in that part of the country; and that the place where the eight inches fell was exposed to the wind from every point of the compass; but those differences were not greater than those between any sunny valley and the mountain-peak in its vicinity.

It may seem superfluous to say that, before the atmosphere can afford moisture to vegetation it must be supplied itself, not only with the quantity that it actually lets fall, but with all that it can retain besides. But this, though an apparent truism, is a truth that must be borne in mind, as necessary to explain some of the apparent anomalies in rain, and consequently in vegetation, as depending upon humidity. Those who have attended to the course and discharge of the partial rain-clouds of summer, cannot have failed to observe how they move toward cold heaths, woods, and the courses of rivers, and shun the dry, open, and warm plains. The air over those places is cold, and tends to augment the cloud, while the warm air over the others absorbs it. A portion of air that contains so much humidity as that if it passed over a thick forest it would blacken in clouds, and pour down torrents, may pass over a desert without haze, and without letting fall a drop. Those who neither observe facts, nor reflect on causes, would be apt to suppose that the portion of England that lies between the Humber and the Thames, embayed as it is by the sea, covered as some parts of it are by marshes, and low and flat as is the whole, would be the most humid within the four seas. So far, however, is that from being the fact, that on the *dry* land in that district (the fens have their own peculiar showers, or fogs rather,) it does not amount to much above half the average for all England, and not to one-third of that for the vale of Keswick, in Cumberland. In summer the warm surface of those countries converts the wind from the sea, which under other circumstances would be moist, into a drying wind; and that wind does not break in showers till it comes to the more elevated grounds in the midland counties. Yet that it is a moist wind we have proofs, in the mist and fog that are produced by it whenever the surface of the ground, and, consequently, the air over that surface, is sufficiently cold.

In temperate climates, this absence of rain on the plains adjoining the sea is a very great advantage. If the rain were to fall there in the same quantity that it does upon the varied surface of the uplands, it would so soak into the ground and stagnate on the surface that the whole would become cold, sterile, and unprofitable. At one period of the history of England it is probable that a very considerable portion of these low and level grounds was occupied by swampy forests, just as many parts of America are now; and those forests, besides occupying the portions of the country which are, from their situations, really the most valuable, must have tended to make the climate both inhospitable and unwholesome. Whether there is a progress toward the other extreme is a question that we need not discuss—the lands alluded to are the best adapted for general agricultural purposes of any in England.

In warm countries the effect is much greater than in temperate ones; and it may be considered as a general fact that, every where within and near the tropics, every portion of flat land near the sea, which is not at the mouth of a river, or in some way kept moist by humidity that it does not derive from the atmosphere over it, is dry and sterile—generally destitute of what we would call herbage. When, therefore, we speak of the exuberant vegetation of tropical climates, we must be always understood as speaking only of those places which are abundantly supplied with humidity. If that be wanting permanently there is nothing but dry and drifting sand, or a soil red and unprofitable, hardened to the consistence of brick, impregnated with nitrate of potass, and covered with other saline efflorescences, which are unfavourable to any but some peculiar saline plants, and the atmosphere over which is by no means healthy for man. In those latitudes there are no evergreen meadows like those that make more temperate climates so pleasing to the eye and so comfortable to the pedestrian. If the ground continues moist for the greater part of the year, then the grass becomes reeds, and the reeds a tall forest; decomposition in the lower leaves goes rapidly on; the constant evaporation, from the great heat, converts the atmosphere into a warm steam, and the whole is unpleasant and unsafe. The forests in such countries are often magnificent; the trees are majestic in their size, splendid in their foliage, and gay in their flowers; and it seems to be continually budding, and flowering, and fruiting. But still the ground is marshy and unpleasant, and instead of herbage under foot the various species of epidendra have their roots in the bark or in the air, and their leaves and flowers displayed from the twigs and arms of the trees. In the low grounds there is no open glade green at all times; for if moist it is cumbered with the exuberance of vegetation in the manner that has been stated; and if dry it is alternately an arid desert and an accumulation of tall plants. The labours of the husbandman are not rendered light in proportion to the increased activity of those powers upon which he depends for his crop; for during the one season he has to keep his plants alive with artificial watering, and during the other he has to war with the jungle.

As the plants are so much modified by the circumstances in which they are placed, the seasonal distribution of humidity becomes an important element in the study of them. The local causes of the differences of that distribution must be determined by observation; but there are some general principles, the knowledge of which is both useful and easily attained. At the opposite extremities of the quadrant the opposing circumstances are different. Drought and moisture are the changes, the extremes, into which climate runs towards the equator, and heat and cold those towards the poles. The causes of both are seasonal; and, therefore, it is only towards the middle of the quadrant, where neither opposing part is in excess, that the weather becomes of that kind which, by the return of rain at short intervals, tends to produce verdure on the surface of the firm land all the year round. For 10° on each side of the equator there is little or no deviation from the state of things there; and thus the verdant middle of the quadrant is not the latitude of 45°, but about 10° more; that is, about the central latitude of England.

The general cause of the seasonal change in the tropical countries is the heating of the northern atmosphere during our summer, and of the southern during our winter; but the action is modified by the situation of the land and the character of its surface. The point over which the sun is vertical is the one to which the winds on the surface of the earth have a tendency to blow. From the real motion of the earth eastward that point has an apparent motion westward; and as the earth, in revolving round its oblique orbit, turns either of its poles more towards the sun than the other, the point has an apparent motion towards that pole. Hence, in the tropical regions of the world, there is a constant wind from the east, or motion of the atmosphere westward; and the centre, towards which that motion tends, shifts northward from December to June, and southward from June to December—the shifting each way being slower at the beginning and end of each period, and more rapid in the middle, according as the sun's apparent declination in latitude is, during the same number of days or hours, greater or less. If the earth's surface were uniform, this shifting would cause a motion of the air on the surface from the south in our summer, and from the north in our winter; and though local causes prevent that from being apparent at all places, it is general, and acts whenever those causes are not strong enough to prevent it.

When this change is from a dry atmosphere to a moist—as when the atmosphere over the Indian Ocean is carried north to the continent of Asia, a rainy season must be the consequence; and when a dry wind is brought—as the wind from Central Asia over the plain of Hindostan, a dry season must ensue. They come at different times, and with different degrees of intensity, according to the local circumstances of the places; but, in all tropical countries which are large enough for being affected by the general action, rain and drought are the seasons; and the habits of the tropical vegetation are influenced or formed in accordance to these.

In polar countries, on the other hand, heat and cold are the chief elements. When the sun rapidly declines away, the cold comes as rapidly; and at the same time that the moisture, which the summer-heat has raised by evaporation, is separated from the air, it is hardened into snow, and falls in that state upon the surface of the ground, ere yet that surface has been much cooled. Snow is a bad conductor of heat; and thus instead of chilling the plants it operates as a mantle in protecting them from the air; and, as in countries that have high latitudes the snow lies from November till April, the vegetables are sheltered during the inclement half of the year. By the time that the snow is gone it is summer, the sun is powerful and the day long, and vegetation proceeds with rapidity and vigour unknown in more temperate climates. Of course the plants of those countries are adapted to the long winter of cold and protection, and the brief summer of rapid growth, and therefore they are as ill-adapted for bearing the alternations of heat and cold, frost and sunshine, that chequer the spring and the autumn of the middle climates, as are the natives of the tropical zone.

The same habits, though to a less marked extent, are found in the plants of Alpine countries, and the more elevated that the place of the plant is, upon its native mountain, the worse it is adapted for bearing the climate of the plain or the valley. On the summits of some of the Scottish mountains, where the snow lies white till June, and falls again in September, or never later than the middle of October, there are delicious mountain-berries, that spurn the art of the horticulturist in the warmest parts of England. In Lapland, the number of these neighbours of the snow is much greater, and generally on all the mountain-ridges there are plants which cannot be reared on the plains without the greatest difficulty. They want their winter clothing—the snow, which cherishes them by preventing all evaporation from their surfaces; and thus, exposed to the chilling nights and the warm days of spring, they are unable to bear the changes of temperature. The earliest sunny day in January or February tempts them into action; they put forth their shoots as if they were in their own native summer; but the cold of the long night comes upon them; their shoots are converted into ice; the expansion of that ice, when freezing, ruptures the vessels; the sun breaks out in the morning to mollify the clods, but it is death to these plants; for the cold, produced first by the melting, and then by the evaporation, of their moisture, completely chills them; the shoots are all gone in a day, and weeks must elapse, even if they are not entirely killed, before another bud can be formed.

Such are the mere outlines of some of those circumstances in the general economy of the globe that modify the nature and habits of plants, and a knowledge of which is necessary to every one who wishes to study the vegetable kingdom with profit, or cultivate plants with success.

CHAPTER III.

SCIENCE AND STUDY OF PLANTS.

BOTANY is the name now given to the science, or knowledge, of the vegetable tribes. It is formed from the Greek Βοτάνη, a plant or grass—that which flocks and herds browse, bleat and low after, and are guided to by the shepherd or herdsman (Βοτηρ). Whether the name be or be not the best adapted to designate the knowledge of all the vegetable tribes, it would be of little consequence to inquire. It has been so used till the use of it is familiar; and thus it is equally expressive of forest-trees or sea-weeds as of grasses.

To trace the history of botany would be a long, and, for our present purpose, not a very profitable inquiry. Like many sciences it began by seeking that which was not to be found by it, and has ended in finding that which the first students had no thought of seeking. As chemistry began in seeking to convert cheaper substances into the more costly metals, so botany began by seeking in plants medicinal qualities which have not been found; but both the one and the other have greatly increased both the speculative knowledge, and the practical advantage, of man. Thus the very failures of the students of nature become grounds of encouragement; because, though they attain not their own objects, they open up the way for others.

What botanical science is, as well as how it may be most easily and successfully attained, will be best seen by considering what we would know, or what it is possible for us to know, respecting any particular plant. The first inquiry is, "What is it like?" What is its general appearance?—what are the parts of which it is made up?—what are the forms of those parts?—and what their arrangement? By carefully attending to these, and being possessed of the written descriptions, we are enabled, when we meet with a plant in the fields, to bring it home bodily or in memory, and by comparing it with the description tell what it is; or, if there be no description answering to it, determine that it is new to knowledge, and find out to what other plants it bears the greatest resemblance. By the very same examination we are able to obtain the converse knowledge; by carrying the description into the field, in the book or in memory, and from that finding the plant.

A second inquiry is, "What is the economy of the plant?" How is it produced?—what are the time, manner, and rule of its growth?—does it flower or does it not flower?—does it flower only once, or does it flower often?—does it last for a season, or for a longer period?—do its leaves stand the winter, or do they not?—does its stem stand or die down?—how is it propagated?—by seeds, without any visible seeds, or both by seeds and by an increase or multiplication of the roots? These and many other analogous inquiries, and minor ones into which they may be subdivided, may be easily and satisfactorily answered by a longer and closer study, or by what may be called an historical examination of the plant. Here, too, the book and the plant have the same mutual usefulness as in the former case: the plant prevents the book from being misunderstood; and the book prevents the observer of the plant from wasting his time in finding out that which has been previously found out by others; brings his knowledge up, as it were, to that of the botanical world, and places him on the boundary, so that he may extend that knowledge if capable and inclined.

A third inquiry is, "Why is the plant there?" Is it a native of the spot where it is seen, or has it been placed there by man? If native, why is it in the particular locality?—on the exposed height—in the sheltered dell—on the sandy shore—the flowery meadow—the marsh—in the river—floating—under the water—or any of those countless localities that a plant may inhabit? If the plant is not native, but has been placed there by art, then there arise many inquiries. Are its appearances and habits still the same, or has it been changed by the culture?—and, if changed, whether for the better or the worse?—and what are the circumstances in climate, in soil, or in treatment, by which the change has been brought about? The answers to these inquiries embrace a wider range than those of the former ones. They connect the plant with the accompanying circumstances; they embrace distinctions of soils, situations, and climates; the modes of transplantation and culture, and the effects and advantages that may thence be produced.

A fourth inquiry is, "What are the constituent parts of the plant, not considered as a living vegetable, but as a portion of matter?" Into what organs could it be divided by the knife, and what is the form, texture, and consistency of those organs?—also, what are their uses in the general economy of the plant. The answers to these inquiries lead to a much more minute and intimate knowledge than could be obtained from the mere inspection of it as a whole, and they have the farther advantage of enabling the plant to be known from a small portion of it. The specific differences even of those plants which in their general habits resemble each other the most, run through all their parts and organs. The flowers may consist of the same parts, arranged in the same order, and very nearly in the same form; and yet there is a specific difference by which careful observation may distinguish them. The seeds may also be very like, and may germinate in precisely the same manner; and yet if they belong to different species there is a specific difference in them that careful observation may find out. It is the same with the buds, the leaves, the bark, the timber, every part of the plant; if it is the same species in one respect it is the same in every respect; and if it is not the same in one there is a difference in all. This is an exceedingly important branch of the subject, not only as it enables us to distinguish between plants, and find out the difference between species and species, and mere varieties of the same species, but as it forms a mental exercise of the most valuable kind. The man of real science is not distinguished so much by the quantity as by the accuracy of his information; and the same distinction holds between the man that is calculated to be safe and useful in life and him upon whom reliance is doubtful. The discernment of small differences —of those apparently trifling matters which the superficial and the hasty overlook — is the very corner-stone of true wisdom, without which there can be no stable building. The sum of a series of the smallest errors may become greater than any single error that could be committed; and as he who through ignorance or want of attention has committed one small error, is, for that very reason, exposed to the very next one, there is no security but a habit of keen and continual scrutiny and watchfulness. Take the example of a road, as an illustration. If a man wished to proceed due north he would not easily be betrayed into a by-path that struck off north-west at an angle; but let the deviation be by a circle of so large diameter that its departure from the straight line were not perceived in any portion of it visible at the same time, and it is not difficult, or at all contrary to experience, to suppose that, by trusting to the imagined straightness as a guide, the man might not only go north-west, but even round the entire circumference, and after much labour and fatigue end just where he began. It may be that there are not many errors of this kind in the paths of topography, for those paths are formed by men with the intention of leading to particular places; but there have been not a few in the paths of science, and some of them in those of the science of plants.

There is another branch of this fourth inquiry —the substances which plants yield; not the products into which they may be resolved by destructive distillation chemically: for with but slight additions, and those not apparently of very much importance, the chemical composition of all vegetable substances is nearly the same:—carbon and water, or the component parts of water, oxygen and hydrogen. They are in different proportions, indeed, in different substances, and they are sometimes accompanied by a little of some of the earths, such as silica or lime; but those that have been stated are the principal ingredients; and the difference between a loaf of wheaten bread and the same weight of a deal-board is much less than those, who are not acquainted with the analysis, would be very apt or disposed to believe. The examination of these belongs to the chemist, but there remains much within the province of the intelligent and useful botanist. What does the plant furnish in the way of honey, or gum, or resin, or wax, or essential oil, or fixed oil, of fibre, of farina, or of any other substance?

A fifth inquiry, and one intimately connected with the last branch, is, "What are the uses of the plant?" Does it yield food; and if so, is the nutriment obtained from the entire plant, from the root, the stem, the buds, the leaves, the fruit, the bark, the juice, or what else? Is it wholesome?—or if not, can it be rendered so by any process of cookery or preservation? The last is a most important matter, and it is not one that calls for much formal science. The gruel or bread of many of the natives of Central America (the *tapioca* of the shops) is obtained from the root of a plant (cassava, *jatropha manihot*) which not only belongs to a poisonous family, but is itself poisonous till properly prepared, when it becomes not only perfectly innocent, but easy of digestion and highly nutritious, though we are in the habit of designating as savages the nations that made the discovery. Plants have in all ages formed a very considerable portion of the food of man; and in luxurious ages they form the most pungent condiments, the choicest relishes, and the most delicious and exhilarating drinks; consequently, were there no other utility, that alone would be a sufficient stimulus to inquiry, and it alone opens a field as wide and inviting as it is rich in useful discoveries.

But it is not only as food for man that the use of plants merits careful examination. All the domestic animals that are most useful to man, that serve him for food or clothing, or work for him, are fed upon vegetables, and therefore it becomes an important question what kinds of vegetables are the most wholesome and nutritious to those animals, and also the most easily obtained; that is, obtained in the greatest quantity, and of the best quality, at the least expenditure of labour.

Then the fibrous parts of plants are useful for many purposes: they may be spun into thread, twisted into ropes, beaten into paper, woven into mats and baskets, and many other things may be done with them. In estimating these there are many points to be determined; such as the quantity in which the plants may be obtained; the quantity of the useful substance that is in them; the proportion that it bears to the labour of obtaining it; the ease or difficulty with which it may be prepared for use; its strength; its durability; and many other considerations, all of which must be found by experiment.

So also those principles, or things, that serve for tanning leather, for dying, for varnishes, for oils, for sugars, for medicinal and other purposes, open a wide and important field to the inquirer, and a field that is not likely to be soon exhausted.

The timber is another important branch of the study, in which all the attributes of strength, durability, stiffness, elasticity, beauty, and every other that can render it in any way fit for the service of man, are well worthy of consideration.

Besides their own intrinsic value, there are many of the considerations enumerated, or that might be enumerated, in this branch of the inquiry, that require an attention to the seasons. The juices of plants are, for instance, obtained at one season, the bark at another, the wood at a third, and the fruit at a fourth; and, according as one or another of these is the more valuable, the season most advantageous for it must be selected.

There is yet a sixth general inquiry: "If the plant is not naturally obtained in the quantity which the wants of society demand, where, when, and in what manner, is it to be cultivated?" The satisfactory pursuit of that inquiry in the wide and general view involves more than even any of the former. The habits of the plant must be known, and so must the soil, climate, and culture—which are the best adapted for promoting its growth and improving its quality. It may be that the best place is a very distant country; and then the mode of conveyance to the consumer or user of it must be taken into the account. It may also be that a great deal of manual labour is required in proportion to the mercantile value of the commodity; and that, whatever may be the nature of the soil or the climate. Thus, for want of soil and climate, cotton, although one of the most abundant, cheap, and profitable articles of British manufacture, could not be grown in Britain; and the same may be said of sugar, which has become a necessary of life with almost all classes of the people. The tea-plant might, in all probability, be made to grow in Britain; but even, though it should thrive as well as it does in China, the manual labour which is required in preparing the leaves would, if paid as the most common labour is, render the price of home-tea more costly than that which is imported from China, even including the duty. It would, however, be impossible to enumerate all the points that demand attention in the culture of plants; for the principles of that culture form more than one science, and the practice embraces more than one art, each of which is occupation enough even for persons of the most cultivated and active minds.

Such are some of the leading subjects that demand the attention of him who would study plants fully, successfully, and usefully. But these are portions of the application, rather than divisions of the study itself; and, therefore, they cannot be resorted to without some previous knowledge, which knowledge may be considered as the general or first rudiments of the science. It has been usual to consider the whole science, or knowledge, of any one class of organised beings, whether animal or vegetable, as made up of the three parts or subordinate sciences of *anatomy*, *physiology*, and *descriptive history;* and it is, perhaps, best to study them in the order in which they have now been enumerated, though, in a merely popular sketch like the present, the shortest and clearest way to the truth is much more to be attended to than the fastidious accuracy of systematic science.

ANATOMY means separating into parts, or considering any compound whole, not as one, but through the medium of the parts of which it is made up; these parts, however, being natural—entire organs as it were, and not merely fanciful fragments, separated from the rest at the caprice of the *anatomist* or dissector. In this, the proper sense of the term, it instructs us in the names, forms, and combinations that make up an organized plant, with their adaptation, from form and texture, to the performance of certain functions, which it is the province of physiology more fully to explain. In the anatomy, the parts are considered merely as matter, and without reference to the mode in which they are called into action. Thus it is the simplest, and therefore should be the first part of the study of plants.

The forms, the situations, and the habits of plants are so numerous and varied, that the terms made use of in their anatomy must not be construed as too rigidly and exclusively meaning the same kind of organ as that in the species which is given as an example. Thus a *root* sometimes means that which bears one stem, and after that stem has flowered and ripened seeds, the root and the stem die together; at other times it means that which, from the same identical portion of matter, sends up a series of successive stems, year after year; or again, it means a new production under ground, formed by the plant of one year and destined to bear the plant of the next; yet again, it is applied to signify at some times a piece of matter that is below the ground, and at others a piece which has the greater part above ground, or even suspended in the air, or floating in the water; or, yet again, it means the under-ground portion of a perennial trunk, which in some cases perishes at the same time with the trunk, and at others survives that, and sends up suckers. Many of the other terms have an equal latitude of meaning; and that they have so must be borne in mind, in order that latitude may not be mistaken for improper applications.

PHYSIOLOGY, to whatever it is applied, means the explanation of the nature or the life of that which is born or produced, as distinguished from that which is mere organic matter, or the workmanship of man. The physiology of plants is, therefore, an explanation, in as far as they can be explained, of the phenomena of vegetable life, as they are displayed in the origin, growth, functions, and decay of plants. It is the application of vegetable anatomy; an inquiry how that which the anatomist describes acts or is acted on in the living plant. It goes much farther than anatomy; because not merely the structure of the parts, but the history of their exercise must be considered. Thus, if the question were the physiology of an oak, we should have to attend to the appearances through a long period of history. The evolution of the acorn upon the parent tree; the germination of the acorn, and the moisture, temperature, and other circumstances that are necessary to make it germinate; the progress of the young plant, and the changes that it undergoes ere it can be said to have the character of a tree; the evolution of its foliage in the spring; the accession and preparation of new matter during the summer; the change of that matter into bark and wood; the change of the alburnum or sap-wood into hearty-wood; the forwarding and ripening of the fruit; the fall of the leaves; the maturity of the tree; the progress of its decay; and its final death. It is the same with the physiology of every other plant, only that of each is modified by its specific character. But those details are the applications of physiology, and the simple and more general principles are those that form an elementary part of the knowledge of plants.

BOTANY, in its proper and restricted sense, is the name of the third and only remaining division of the study of plants; and the botanist either considers plants in their individual or specific characters, or as arranged into groups that have a greater or smaller number of appearances in common. Other than the species, which are the only absolute distinctions of nature's making, the whole of the arrangement depends upon the skill or fancy of him who makes it. But still there are among animals, and so also among plants, certain natural resemblances; and it is not unnatural to say that there is a closer relationship between those that have those resemblances than between those that have them not. Both among animals and among plants some of these resemblances are more general and some more particular. Thus any quadruped, or four-footed animal, having warm blood, has much more resemblance to any other quadruped, how different soever they may be in every thing else, than it has to a bird, a reptile, or a fish. In like manner there are classes of plants which, though they differ from each other in many particulars, have yet a sufficient number of appearances or characters in common to induce us to consider them as belonging to that class, and not to any other. Thus, among animals, though a lion, a tiger, and a cat have specific differences that are definite enough, and prevent those who are acquainted with them from ever mistaking the one for the other, yet they have all as much in common as leads us rather to class them with each other than with a dog, a fox, and a wolf, among which we find a similar coincidence. Plants have not so many or so active qualities as animals: they do not move about or perform any of the animal functions; but still they have characters sufficiently marked for enabling us to trace a relationship. Thus the least observant or reflecting person would at once see more relationship between a pine and a yew than between either of those trees and an oak; and there is nobody who would not at first sight conclude that barley stands in closer relationship to wheat than it does to beans or turnips.

This grouping, when it is formed, not upon mere fancy, but upon a careful observation of nature, is of the greatest use, and conduces more, perhaps, than any thing else to simplify, shorten, and smoothe the study. Well chosen, too, it is in strict accordance with philosophy. We have nothing but organization whereby to judge of the productions of nature. If the organization of any two individuals were so perfectly alike that the one might be substituted for the other, we should not hesitate in saying that they were not the same species merely, but the same variety; and in as far as we found the organizations to agree, in as far would we infer a similarity of functions. A classification of this kind is the instrument by which, in all sciences, and in none more than the science of nature, we "divide and conquer." We detach one group and master that; after which, we detach and master another; and so on till we master the whole. And the advantage in the way of shortening is, that when we have examined and established one fact, and ascertained its connexion and consequences, that fact, with all which depends upon it, goes to the store of general knowledge; and we, without a new investigation, know it again, in all its extent, wherever we find it.

Some of the systems, according to which plants have been classed, will be noticed after we have taken a rapid glance at the anatomy and the physiology; but there are some of the greater natural distinctions which we must previously notice, in order to make those parts of the subject intelligible. One distinction is this: all plants either have visible or known flowers, or they have not. Those that have the flowers visible are called *phenogamous*, which means nearly the same as, "having visible flowers;" and those that do not belong to that division are called *cryptogamous*, which is much the same as saying, "not having visible flowers." All plants are, therefore, either *phenogamous* or *cryptogamous*. Phenogamous is a positive and definite character; and, when the flower of the plant has been seen, there remains no further room for dispute about it. Cryptogamous, on the other hand, is negative, and simply means that the flower of that particular plant is not known, or has not been seen; and, consequently, when the flowers (or rather the seeds of the plant, for it is the seeds that are the real object at issue,) are discovered, the plant must be transferred to the phenogamous division. Some plants have been so since the distinction was first made; but the point is one requiring great caution, especially in those cases where the microscope must be had recourse to. When a high magnifying power is employed, it is not very easy to institute a comparison with subjects for which such aid is not required; and as it is extremely probable that in some cases fermentation has been mistaken for animal motion—death, even dissolution, for life, there is much danger that mistakes may arise in the microscopic observation of plants. Still, as the circumstances of flowering and not flowering are, within certain limits, accompanied by peculiarities in the anatomical structure, and also in the distribution of plants, in latitude or in climate, they are worthy of attention.

If the well-defined plants of these two divisions are to be named from their anatomical structure, those that flower are found to have in their structure tubes or vessels, which at one period at least of their existence contain fluids—and possibly convey them from the part of the plant where the nutriment is taken in, to that where the addition is to be made by growth, while those that do not flower have their structure wholly made up of cells. Phenogamous plants are, therefore, the same as VASCULAR plants, or plants having prolonged tubes or vessels; and cryptogamous plants are the same as CELLULAR plants. It is not meant to be said, however, that the one class is wholly made up of vessels, and the other of cellular tissue; for both classes have cellular substance, and the vascular ones have the vessels, in addition as it were, just as they have the flowers.

Among the phenogamous or vascular plants, there is a very important distinction arising from the mode of growth. That is, the manner in which the mass or body of the plant increases by the addition of new matter. In the one division the active part of the plant is the centre, and the addition of new matter takes place there. Such plants are said to be ENDOGENOUS; that is, to grow or produce at the centre, or from within. In the other class, the active part is at a distance from the centre, surrounding it, and between the wood and the bark. They are called EXOGENOUS, growing from without or at the outside, the outside not meaning the absolute external surface of the plant, but the boundary between the wood and the bark, as already stated. The difference is, that the endogenous plant increases from a mere visual line, as it were; that from that line outward to the circumference every successive portion is older than the portion within it; that the whole stem, whatever may be its structure, bears, with reference to the immediately vital part, some resemblance to bark, and the surface being the hardest part. On the other hand, the exogenous plant grows at the circumference of a cylinder; and every additional growth gives a double product, one part of which goes to increase the cylinder within, by an additional layer of matter round its external or convex surface, and the other goes to increase the casing or bark outwardly by an addition to its inner or concave surface. The proportion in which this distribution takes place, and also the character which each portion of it assumes, varies with the species.

It is not easy to imagine how a vegetating cylinder could be evolved by a line, or that it could be so evolved at all; and accordingly we find that all exogenous plants have a *pith* or centre, which is never vascular, or appears to contribute actively to the growth, after the cylindrical form of growing and the separation of bark and wood have been established. In the early stage of the stem or twig, say the first year of its growth, the pith occupies a large portion of the whole, and is succulent and full of juice; but it is to be borne in mind that at that period the vascular part of the stem is merely in the act of forming, and that it needs support, and probably nourishment, from the pith. But, as the plant increases in size and strength, the pith dries and diminishes in substance; in some cases it is nearly or wholly obliterated by the closing together of the wood, and in others it wastes away and leaves a hollow cavity: the portion contained in a twig of one year's growth has often ten times or a hundred times that of the larger tree, of which the said twig forms but a very insignificant part.

There is another distinction which marks the endogenous and exogenous plants, and that is, the number or position of the lobes of the seed. These lobes are called *cotyledons;* and the endogenous plants are said to be MONOCOTYLEDONOUS; that is, to have one cotyledon or lobe in the seed; and the exogenous to be DICOTYLEDONOUS, or to have two.

Numerically, the application of these names is not in every case correct; for some of the first class have more than one cotyledon, and some of the second have more than two; but the cotyledons of the exogenous plants are always opposite to each other, forming, as it were, halves or parts of one whole, as may be seen in a pea or bean after it has been boiled; while the cotyledons of endogenous plants, where there are more than one, are alternate to each other, and each appears to be more complete without the other than in the former case.

Thus it is to be borne in mind, as a first step in botanical knowledge, that there are two divisions of plants: cryptogamous, or those that do not flower, and that they are wholly cellular in their structure; and phenogamous, or those that do flower, and they in all cases have the cellular tissue more or less mixed with vessels, and thus are, or may be denominated, vascular plants. Then there is a division of the vascular plants into endogenous and monocotyledonous, or those that grow only at or from the centre, and have one lobe or alternate lobes in the seed; and exogenous and dicotyledonous, or those that grow at or from the outside, and have two or more opposite lobes in the seed. Farther, the vessels in the endogenous plants are scattered through the stem, which, except less rigidity in the central parts, has no necessary difference of structure. On the other hand, the stem of an exogenous plant always consists of three distinct parts,—the pith, the wood, and the bark; and, during the time that it is in active vegetation, it has a fourth, between the wood and the bark, which is not yet a portion of either, but destined in time to be divided between them. In glancing at the leading points of vegetable anatomy, we shall consider chiefly the exogenous plants, because their parts are the most numerous.

CHAPTER IV.

ANATOMY OF PLANTS.

THOUGH the structure of those plants that have it the most complex, and which are on that account styled, in common language, the most perfect plants, be much more simple than that of animals, yet the anatomy of plants involves difficulties, and is attended with uncertainties, from which the anatomy of animals is entirely free. The cause is this: there are in an animal certain definite functions, and the organization adapted to each of these may be examined separately; and, as we know what the function is, we can, in general, easily tell whether any particular organ ministers to that function or not. There is the sentient or nervous system, with the brain, in those animals that have vertebral back-bones, and the ganglia in those that have not; there is the circulating system, by which the blood is alternately carried to and from all the parts of the body; there is the respiratory system, by means of which air is so brought in contact with the blood that the oxygen of the air mixes with a portion of carbon and carries it out of the system in the state of carbonic acid; there is the nutritive system, by which food is taken into a local stomach, prepared, and ultimately mixed with the blood; and there is the absorbent system, by which parts and substances that have ceased to be useful or wholesome are taken up and discharged. The organs that belong to these are all easily distinguished from each other, and their uses are known.

In plants there are no functions analogous to these, neither is there any thing that can be considered a system having a centre in plants. There is no nervous system; no circulation, at least none resembling that of animals. There is no internal organ of respiration, nor any tube or vessel that we can consider as being adapted for the conveyance or circulation of air. Nourishment is taken up by the roots, as is generally supposed; but we do not know precisely what it is that is so taken up, and there is no local stomach in which it can be assimilated. As little is there any absorbent system; and we know of no matter that is given out by plants, when they are in a growing state, except gases; and thus there cannot be presumed to be any absorbent vessel for taking up superfluous matter in the interior of plants. Indeed, we know that there can be none such; for when part of a plant rots it is never taken up or removed, except by causes external or foreign to the plant. There are, indeed, certain absorptions that take place in plants, but they are all connected with the bringing out of some nutritive substance from cells or other stores in which it had been deposited. Thus the farinaceous matter in seeds and in tuberous roots is absorbed for the nourishment of the young plant; and it is possible that the substances at one time deposited in the cells is absorbed by the vessels at another; but how, or by what means, those absorptions take place has not been very well ascertained; nor has any set of vessels, for the latter purpose especially, been discovered.

But the anatomy of animals was well understood before that of vegetables; and thus some of the names that are made use of in the one science were adopted in the other, and to the unthinking brought part of their signification along with them. Thus we hear of the *medulla* (or spinal marrow cord) of plants, of veins, of nerves, and other matters analogous to those of animals. Such words applied to plants have, however, no meaning, and therefore the use of them had better be abandoned, and the terms *cells* and *vessels*, only, made use of, modified by such epithets as may express their forms or well-established uses. It will be convenient to divide this chapter into sections.

SECTION I.—CONSTITUENT STRUCTURES OF PLANTS.

The structure of every plant consists of *cells* or of *vessels*, or of a union of the two. These cells or vessels may be empty, or they may be filled with fluids of various kinds and consistencies, or with farinaceous or starchy matter; but still every plant, and all parts of every plant, has its sustaining and containing structure, either cells or vessels. The cells may be of various shapes; the vessels are generally, if not always, cylindrical pipes.

Cellular Substance.

The cellular substance of plants consists of a number of little cavities, of various shapes and sizes in different plants, formed of membrane, and generally so placed that in vascular plants the rows or courses of the cells are at right angles to the straight vessels. Sometimes these cells are very minute. Dr. Hook estimated more than a million of openings in the surface of a square inch of cork; but in other cases they are larger, and in some as large as a common pea. They are of various shapes, but the hexagon, the form of the cells of bees, is the most prevalent. It is generally understood that, though the cells be in contact, each has a perfect coat of its own, though from their extreme thinness it is not easy to separate, or even to distinguish, two that are in contact. The coats of the cells appear to be entire, without pore or opening of any kind by which they may be either filled or emptied; and this furnishes us with a very striking instance of the singular way in which nature can work. The coats of these cells are so thin that they are a mere pellicle; they are, in some cases, so minute as not to be discernible by the eye; they are sometimes full of substances of considerable tenacity or consistency, and at other times they are empty. Those partitions, thin as they are, must therefore have the power of secreting or elaborating their contents at some times, and of absorbing them at others. Those cells, indeed, contain, and in all probability elaborate, all the peculiar juices and products of plants. The farina, the gums, the resins, the oils, the acids, the sugars, the colouring matters, in all their endless varieties, are the products of these little cells; and thus they are a set of laboratories with which those of human chemists cannot bear one moment's comparison. Cork has been mentioned as containing very minute cells—1200,000,000 in the cubic inch; and yet these mere points secrete an acid (the *suberic)* equal to one-twelfth of the cork. The cells of some plants secrete food—as in seeds and roots; others secrete the constituent parts of wine; some give spices, others cooling acids; and, in short, there is hardly an effect upon sensation, other than the sense of hearing, that may not, in some way, be produced by what is elaborated in the cellular tissue of plants. That tissue, too, is the uniting substance of the plant—that by which the other parts are held together.

It would be foreign to our purpose to take any part in the controversies that have been entered into by vegetable anatomists as to the structure of the tunics or walls of those cells, or the manner in which they are originally formed; as the parts are too minute, in the first case, for admitting of satisfactory dissection, and the process is too much hidden, in the second, for admitting of explanation. Whether the vessels are or are not formed by means of the cells, the cells are in the whole plant, or in a young twig, anterior to the vessels; but, again, there is no question that after the plant has attained a certain size, cellular substance is added to it *by the help* of the vessels—at the same time it is not established that a bud can be produced in any part of a plant where there is not cellular substance, nor in every part where there is. There is less question that the cells are diminished in size, altered in shape, and often obliterated, by the increase and induration of the other parts; and that even where not compressed together they sometimes shrink of themselves and leave openings. That the hardness and durability of timber depends, in all cases, on the compression or obliteration of the cells, it would be too much to assert; but it is true that the cellular substance is neither so strong nor so durable as the vascular; and it is by no means improbable that sap-wood changes into hearty-wood when the cells become so deeply imbedded under the new layers of wood that the heat and the air cease to have much action on them.

Vascular Substance.

All those that are usually described as the fibrous parts of plants, whether they be wood or bark, are formed of vascular substance; and there is every reason to suppose that, divide them as we may, the ultimate positions at which we arrive are hollow tubes and not threads. The smallness of the diameters of these vessels is still more surprising than the cells. Hook estimates that there are in a square inch more than seven millions and a quarter. Leuwenhoeck estimated that there are in the bole or trunk of an oak, only four inches in diameter, two hundred millions of vessels; and at the same rate, Damory's oak in Dorsetshire, which was eighty-four feet in circumference, must, when entire, and without the hollow that was latterly in the centre of it, have contained no fewer than 1,441,200,000,000 vessels in a single section of the trunk; a number which, to human understanding, may be regarded as infinite. We speak of about perhaps a thousand miles of pipes that are laid down in the city of London, for the conveyance of water and of gas, as something wonderful; but there were more than 240,000,000 of miles in one foot in length of Damory's oak, and more in the whole tree than would have made a communication backwards and forwards between the sun and every planet in the system.

As there is no centre of circulation from which the fluids of plants are propelled, as is the case with the blood of animals, or to which they again return, their vessels are not branched into ramifications like those of animals, neither do they anastomose or unite laterally with each other. They are cylindrical, every where of the same diameter, and have no lateral communications. These vessels do not occur singly, but in bundles, or fasciculi, containing a greater or smaller number, not only in different plants, but in different parts of the same plant. In what are called herbaceous stems these fasciculi are placed apart from each other, spread through the cellular substance, as it were, but in the trunks and branches of trees they are close together. The fasciculi often branch off, join other fasciculi, separate again, and join the former, and thus form a species of net-work, though without any communication between the cavities. Their position is always, upon the whole, in the length of the stem or branch; but they vary so much in their direction, and also in their proximity to each other, as to produce all the variety of grain and curl in wood, which, when the varied courses of the vessels are cut by a plane at various angles, often produces a beautiful display of colours—of which we have instances in mahogany and many other woods that are used for ornamental purposes.

Still, even in a leaf, where the vessels appear to ramify into smaller parts, the greater size is only a more numerous bundle; and the same may be said of all other cases. The more straight the vessels are, the more easily is the substance divided in the direction of its length. The vast number and extreme minuteness admit of an endless variety of points of division. The most easy separation is into the natural fasciculi; as we find that, though the cleaving of a billet of wood be begun by the straight edge of a very smooth axe, the split will, as soon as it becomes a tear, be full of ridges and furrows. In many species of timber the yearly concentric growths are the most easily separated, and the next easiest section is at right angles across them. An oblique rent is made with difficulty, and its direction is always uncertain. Renders of laths and hoops avail themselves of these facts; the former, by taking the line of the growths, and across that line; and the latter, by dividing the twig, or sapling, as nearly as possible through the centre of the pith. In timber which cannot be cleft without difficulty, or in any thing approaching to a straight section, the fasciculi of vessels cross each other very much, as may be seen in lignum vitæ and many other species. In many trees, too, there are curious bendings and contortions of the vessels at the separations of the branches.

Though all the vessels that are found in the woody or ligneous part of a tree perform the same office—contain sap, and transmit it to the buds, leaves, and twigs, when it is required for the purposes of growth; yet they are of different structure, from which, though probably not with much reason, it has been inferred that they have a difference of use. One set of those vessels, and they are generally speaking the smallest in diameter, appear to be continuous tubes, and not to admit of any separation into parts but by an actual division of their substance. These have got the name of *common* vessels. There is another kind, generally of larger dimensions than these, that are formed of a little fillet or fibre of matter curled spirally round, and something resembling the tube which is formed by the coiling of one wire round another, and then withdrawing the last. These are called *spiral* vessels: but it must be kept in mind that it is not the vessel but the substance forming its sides that has the spiral form. The analogy that fancy may trace between these spires or rings in the vessels, and the cartilaginous rings in the windpipe or *trachea* of an animal, has sometimes led to the mistake that they are tubes for the conveyance of air; but they contain sap, in the same manner as those vessels in which the spiral structure has not been detected.

With the exception of the bark, in which they have not been found, these spiral vessels are met with in every part of vascular plants. In the wood, in the petrales and ribs of the leaves, and in the petals of the flowers. They are more abundant in some species than in others, and in different plants they are most abundant in different parts; but the difference of function arising from their being more or less abundant has not been noticed, and therefore the use of the spiral structure is not known. That they contribute in some way to the propulsion of the sap, which could not be effected by the vessels that are not spiral, is probable. How this is done has not been, and possibly cannot be, ascertained; but we know that when any spiral portion of vegetable fibre is wetted it contracts in length and increases in diameter; and therefore it *may be* that such an action in the spiral vessels of the living vegetable tends to propel the sap onwards in those vessels that are not spiral. Some countenance is given to this supposition by the fact that there are no spiral vessels in the bark: but the matter, though exceedingly curious, is very obscure. Another fact may be mentioned as tending to confirm the same opinion: in herbaceous stems the spiral vessels are generally surrounded by, or, as it were, sheathed with, common vessels, which would lead to the conclusion that they mutually assist the action of each other; and unless we allow of some such action it is difficult to conceive by what means the sap is propelled with the force that it displays. It is true that most, if not all, the vessels in a plant are capillary; but, though that might account for their being filled by the sap that enters by the roots, it would not account for the force with which the sap pushes in the evolution of new parts, at the extremity of a remote branch, or issues from a wound there.

The spiral portion of the vessel is not made up of a single flat fillet, but of a fasciculus of round fibres (probably themselves tubes or vessels); and the coils of these fasciculi are not generally in contact, but have their interstices closed by the membrane of the cellular tissue—a structure which would favour the action that we have ventured to conjecture. The openness or closeness of the spires, and the union of different parts of the fasciculi in the same vessel, or in different vessels, has led to the classification of spiral vessels into different kinds; but, as no difference of function has been found to accompany these, the difference of appearance is, in the meantime, of little use. There is some reason to suppose that the spiral vessels undergo modifications by age; and that, as they recede more and more from the active part of the tree, by the addition of new matter at the outside, they not only become smaller in their dimensions, but have their spiral character obliterated by the sides of the fasciculi adhering as closely as the individual portions of which they consist. That change is always accompanied with a decreased action in that part of the tree in which it takes place. The diminution is increased by solid partitions, which, in the course of time, form across the openings of the vessels; when that has gone on for some time the action ceases altogether; and soon after that the wood begins to decay. The partitions have been sometimes mistaken for valves, intended to prevent the backward motion of the sap—in the same way as the valves in the vascular system of animals prevent the backward motion of the blood. But in the active vessels of plants there are no valves; and there is no use for them, as there is not in the plant any central propelling organ, like the heart in animals.

Whether, therefore, they be spiral or not, we are to consider the vessels that make up the woody or fibrous part of plants as having all the same function —that of conveying sap, and also as being of the same dimensions throughout their length. The only other consideration is their terminations. On this point it may be stated generally that the termination downwards is in the absorbent rootlets, by means of which plants draw their nourishment from the soil; and that they terminate upwards, either where the different products of the plant are elaborated, or where some matter is exhaled into the air.

General Action of the Vessels.

In trees which hybernate, or remain inactive during the winter, an internal action takes place in the spring, before the buds expand or there be any other external sign of activity. The vessels, which, during the winter, were empty or filled with concreted matter, become filled with sap; that sap is of varied composition—in some cases it is insipid, in others bitter, and in others, again, it is sweet, sugary, and easily rendered slightly vinous. Perhaps it contains sugar in all cases, though in some the taste may be concealed by other tastes; for sugar seems essential to vegetation in every stage, from germination upwards. This sap is sometimes so plentiful in quantity, and so rich in saccharine matter, that it is, as in the case of that of the sugar-maple in North America, largely employed in the manufacture of sugar. This sap is found only in the wood, the bark at that time being dry. It is also first found nearest the root of the tree, and its gradual appearance in the other parts is called " the rising of the sap." Whether it actually rises, is a physiological question, and will be noticed in the next chapter.

As soon as the seasonal action of the tree has become apparent, in the opening of the buds and the pushing out of the rootlets in the soil, the sap begins to be found in smaller quantity in the wood; and it no sooner ceases to flow from the wood than it is found abundantly in the inner layers of the bark, and between the bark and the wood. This change in the distribution of the sap does not take place till the leaves are developed; and if the leaves, as they make their appearance, be carefully pulled off, or if they be eaten by insects, or destroyed by any other means, the change does not take place at all. Thus the general function of the leaves is seen; and their particular functions may be found by comparing the sap as existing in the wood and in the bark, and noticing the difference in its properties. Though connexions are often very conspicuous in the section of the wood, in the form of rays proceeding from the centre to the circumference. These *medullary rays*, as they are called, are very conspicuous in beech, and still more in the beef-wood of Australia *(casuarina torulosa)*; they are also very conspicuous in oak, especially in that which is straight and of rapid growth. They form what workmen call the "champ" of timber, and exhibit considerable surface when the tree is sawed or cleft upon a radius. In the sapwood of some of the softer trees of New Holland the quantity of this cellular substance is so great that the vessels form a very loose and open kind of net-work, and the consistency is often so soft that it may be separated by maceration in water—just as the cellular part of a leaf may be separated, and only the vascular tissue left.

The Wood.

As wood is synonymous with vascular tissue, it must exist in all parts of vascular plants, though it is not till after a certain period of growth that it is distinguished by superior firmness and consistency. The vessels, or fasciculi of vessels, are not, however, in absolute contact with each other, even in the most compact timber. They may always be traced in rays, or lines, from the centre outwards, and separated from each other by cellular matter. The annual additions, or layers, or rings of wood, are also separated from each other by that tissue, and so are the rows of vessels of which the annual layer is composed. It appears, therefore, that while the vessels are the strength of the wood in the direction of its length, the cellular matter is the cement by which the whole is united together. Thus there is a resemblance in structure, though not in functions, between the wood of plants and the muscles of animals. The elementary filaments of which the muscular fibres are made up (whether they be tubes or solids), are as slender as the elementary vessels of plants; they are united into fasciculi, and the fasciculi are formed into one entire organ, by means of cellular substance. In both, too, the cellular substance is more easily destroyed than the parts which it holds together. Boiling separates the fasciculi of the muscles; and the process of charcoal-making renders the vessels of wood more apparent by consuming the cellular substance. From the last operation it should seem that the vessels contain more carbon, and the cellular substance more of the elements of water.

The arrangement which has been now described is that which takes place in exogenous stems which last more than one season, and to which the term woody or ligneous is usually applied. But there are two other forms, one of them found in herbs, or herbaceous plants, and the other in palms.

In herbaceous plants, the greater part of the stem is composed of cellular substance; and the fasciculi of vessels are usually at considerable distances from each other; but sometimes they are in layers. One of the most peculiar structures is found in the bulb of a turnip; though the peculiarity is most striking in the second season after the flowering stem has been produced. When the turnip is grown in a proper soil, and not too warm a climate, the bulb, even at the close of the first season, does not exhibit much of a ligneous or vascular structure. If, indeed, the bark is removed, the surface of the remaining part is found marked with a very beautiful net-work; but, under the circumstances mentioned, that net-work does not, in consistency, differ from the rest of the bulb; the whole being a cellular substance, without almost any trace of vessels. If the climate has been too warm, the vascular substance is developed earlier, and the bulb is full of vessels, which do not soften in boiling. In all cases, however, when the flowering stem is produced, the cellular substance in the bulb, which seems to be a reservoir of matter for the production of that, loses much of its cellular structure and shrinks; but, at the same time, the net-work of vessels on the surface acquires the consistency of wood, and may be separated. In the stem of a cabbage or colewort, the fasciculi of vessels may, in like manner, be seen surrounding the cellular pith, which retains its succulent nature till the plant flowers.

In the palms, the wood is still different in structure. The cellular substance is hardly changed by age; and the vessels are promiscuously scattered through it in very firm and strong fasciculi, which can, however, be divided into smaller portions. These plants have, indeed, no distinction of pith, wood, and bark; and probably the best mode of describing them is to say that all these three structures are blended together.

These different forms of the wood are not mere matters of internal or anatomical observation, but are accompanied by corresponding external appearances and modes of growth. Where the annual additions are made by layers applied to the outside of the wood, the vessels must be arranged in concentric rings; and a certain degree of resistance to the enlargement must be made by the surrounding bark. The cellular texture is the part most easily compressed; and if we consider the cells as being in part reservoirs, out of which the substance of the new wood comes, they must be nearly empty at the time when it is acquiring its greatest consistency, which will render their compression the more easy. The original nature of the bark, as well as its age, and the state of health in which it is, must modify that compression. When it becomes so dry as to be no longer expansible, it is either burst and cracked by the action of the tree, or, if the action be not powerful enough for that, the tree becomes what is called "bark-bound;" its action diminishes, or it ceases altogether, and the tree dies. In the early stages of that malady, the tree may be relieved by slitting the bark longitudinally; and the sides of the slit will often start asunder to such a distance, as to show that the pressure which resisted the formation of new wood was very considerable. When the whole bark becomes indurated, new vigour may be given to the tree by paring it down to those layers that still have vegetable action; or, if the paring be carried nearly to that point, the remaining portion will soon be rent into fragments, and new bark will appear in the fissures. By any of these modes of treatment the tree may be made to increase much more rapidly in diameter, and to put out much more vigorous shoots, and broader and fresher leaves. A tree which has a soft and yielding bark, or of which the bark may be split lengthwise by little force, always produces soft and spongy wood. This is true not merely of different species of trees, but of different individuals of the same species. Lime-trees have much softer bark than oaks or beeches, and the wood is correspondingly softer. The same is the case with the spruce as compared with the yew or the cedar of Lebanon. The Dutch elm has a bark that is easily split, and the wood of that tree is of little value. The chesnut, on the other hand, has very firm bark, and the timber is equally firm and durable. In the same species, again, the gnarly oak or hawthorn that stands on some bleak eminence, exposed to every blast, and not acquiring above a few inches of additional height in a lifetime, has its wood as iron, compared with the stately tree that grows in a rich soil and a sheltered situation. Due attention to this action and resistance would enable cultivators to obtain timber of any consistency they might desire.

Though the herbaceous stems are much less affected by compression than trees, they are, like them, found to be harder, and less succulent, when they are stunted in their growth; but as their duration is only for a single season the difference is by no means so conspicuous.

The peculiar structure in the wood of the palms accords well with the singular mode of their growth. When they fairly begin to rise in a column there is no further enlargement of the diameter. The leaves continue to augment and increase the neck of the root for four or five years; and it happens in many of the species that this enlargement takes place above ground, and additional roots are put down from it round the original one, till the base of the column appears to stand upon a number of feet. After a time, however, the root begins to ascend, the young leaves are formed from the centre of the crown, the lower ones in time drop off, and the stem ascends without any increase of diameter. In the interior of the column of the palm there are no indications of its age, as there are of the duration of a common tree in the annual rings of wood; but the age of the palm is registered on the outside, where every leaf that falls off leaves a circular impression. The development of the palm in growth takes place entirely at the top. The cellular tissue and the vessels increase only in length; it has, therefore, the same freedom of action in the trunk at all times, and hence its cells remain unaltered, and its vigour continues for a very long period. So long, indeed, as it is not cut, and no injury is done to the crown that produces the successive leaves and elongations, there appears to be fewer of the elements of decay in a palm than in a tree of any other kind. It is not, therefore, from the beauty or grandeur of their leaves alone that palms are made the emblems of victory and immortality; for in themselves they are the least mortal of the vegetable tribes.

The Bark.

It has been mentioned that there are no spiral vessels in the bark, and no motion of any juice outward, but in other respects, as well as in its formation, it bears a considerable resemblance to the wood. In the formation of annual rings of new matter it is probable that the bark and the wood both act their part, and the product is divided between them. The ratio in which the division takes place varies with the kind of tree; but it may be stated as general that more goes to the wood than to the bark. In those trees that have the rings of the wood conspicuous, the rings of the bark are conspicuous also. This might be supposed, because, as is very expressively remarked by Grew, the bark is not a mere covering to the wood, but the two are both essential, and equally essential, parts of one structure. The wood could no more produce one new cell or vessel without the bark, than the bark could do it without the wood; they are, in consequence, united by many cross ties or ligatures, composed of cellular substance, having their one extremity constantly in the wood and the other in the bark, and easily divided only when the annual supply between the bark and the wood is yet in a fluid state. As the yearly additions within the bark cause an increase of the circumference, the bark is stretched and at the same time compressed by the enlargement till the cells that are in it assume a flat form. The form which the compressible parts, both of the wood and the bark, must assume, may be easily inferred from the force that acts upon them, and the place and manner of its action. That force is an expansive one, acting on the cylindrical ring; resisted, on the one hand, by the cylinder of wood that is within, and on the other by the bark without. The wood is solid, and must make the greater resistance; and, as the outer rings of the bark are stretched without any increase of substance, they must, if they do not crack, become thinner.

If the tree be of a kind that secretes or elaborates any particular substance—as gum, resin, or any thing else—that substance may be expected to be found in the cells of the bark as well as in those of the wood. Thus we find turpentine in the bark of the pine-tree, and manna exudes from the bark of some species of ash. As the bark is more exposed than the wood, the air and the temperature must have much more influence upon it; and accordingly we find that many active principles are in quantity in the bark of which there is none, or very little, in the wood. Upon this principle the barks of various trees furnish aromatics, and dyes, and tanning substances, for which the wood of the same trees would be but a sorry substitute.

As herbaceous stems contain much more cellular substance throughout their whole mass, at least when they are in their green and growing state, than trees, the bark in many of them cannot be so well defined; but still, in all those that increase in diameter at the outside, there are sap-vessels within the circle of increase, and proper vessels without; nor is there much doubt that they form their additional matter much in the same way as the others.

As the roots of plants are placed in different circumstances from the stems and branches, it is natural to suppose that those circumstances must impress upon them differences of structure. The power which a growing vegetable can exert is not, perhaps, more forcibly demonstrated in any thing than in the separations of masses of rock containing many tons, which are effected by the insinuation of the roots of trees between them. But still, as we find that the vegetable adapts itself to compression, and as the compression of the root below ground by the soil must be greater than that of the plant above ground by the air, we may expect a corresponding difference of structure. Accordingly the vascular or ligneous structure prevails much more in roots than in stems; there is less pith, and sometimes none at all; the bark is usually thinner in proportion, and the whole structure is more firm and compact. Something of the same kind holds with regard to the stem; the root end is always, if not begun to decay, the best and hardest timber. The roots of many herbs, too, of which the stems are, for great part of the season, cellular, are firm, and contain a number of vessels; and one of the labours of art is to cultivate useful roots out of that structure, by inducing them to accumulate a greater portion of cellular substance. Sometimes the cellular matter thus accumulated is in the form of pith, as in the case of the turnip; and sometimes in the form of bark, as in the case of the carrot. Even where the bulb is not one solid, but consists of a number of plates or scales, as in the onion, the same accumulation of cellular matter may be effected by culture. Though no useful inference can probably be drawn from it, there is here an analogy between animals and vegetables which is at least worthy of notice. When either the one or the other is supplied with more abundant or more nutritive food than it obtains in its natural state, the consequence is an accumulation of cellular matter, under the form of fat in the animal, and farinaceous, fleshy, or juicy, in the vegetable. It is farther worthy of remark that there is a considerable resemblance between the structure of the cellular texture in animals and in vegetables. The adipose matter contained in the cells of animal fat does not appear to be a deposit from any circulation, but rather a secretion by the walls or coats of the cells; and the cells do not appear to have any openings, but must empty themselves by a species of absorption. It is the same with the cells of vegetables; and in both cases the contents of the cells seem to be a store from which the plant or the animal can draw according to its necessity. Farther; animals in a state of nature appear to collect a quantity of this cellular matter during the early part of the winter to assist in their new action in the spring, and plants apparently do the same.

The Epidermis or Skin.

The epidermis is the last or external covering of plants, and it covers them in every part—in the root, the stem, the branches, the leaves, the flowers, and the fruit—varying in appearance with the species of plants, and also in the different parts of the same plant. There are exceptions; but it may be said that in general the skin is thickest upon the trunk, then the branches, the root, the leaves, and the flowers. There are exceptions, however; as those leaves that have to bear the cold of winter, or the heat of a dry season in the tropical countries, and also those of plants that grow in dry situations, have a much stronger and firmer skin than others.

The skin of plants varies very much in appearance. In young plants, and on many leaves, it is colourless, or, if removed, of a pale whitish tinge, so that the colour is that of the parts below, which is only softened a little by the skin. In older plants, however, the skin is variously coloured, and when it is taken off, the colour of the bark below appears very different. The skin, indeed, forms a character by which the species of trees may be distinguished; the white birch, the grey oak, and the brown beech, are descriptive of the trees, as much so as any single epithets that could be chosen.

It is probable that a new skin is formed every year, as well as a new layer of bark and of wood. In some species the old skin comes off in scales, in others it comes off in patches, and in some sycamores there is an exfoliation in large thickened masses. The most remarkable exfoliation takes place in the trees of Australia, more especially in some species of *eucalyptus*, in which the whole tree looks white, as if denuded of its entire bark; and in those trees, as well as in the sycamores, to which allusion has been made, certain layers of the bark exfoliate along with the skin. Other trees, however, retain the annual layers; and in the birch, especially, ten or a dozen may sometimes be separated, all very thin, and the inner ones having a fine silky gloss.

Is this skin of vegetables a simple membrane, or does it consist of several parts? Many circumstances support the latter opinion. In the leaf it is the only covering to the cellular tissue or *parenchyma*. Caterpillars, called *miners* by Reaumur, eat out the parenchyma very completely, and leave the skin; and the skin is then found to contain in its inner part a vascular tissue in the form of a network, with variously-formed meshes, according to the nature and functions of the leaf. When one of the surfaces of a leaf is absorbent, and the other not, there is a corresponding difference in the vascular web of the skin, and by carefully macerating the leaf in water these may be distinctly seen; for though the living skin resists the action of water probably more than any other part of a plant, it yields to that action when the vitality has ceased. The skin of plants, then, even when so thin as to be transparent, is not a mere extension of membrane, but an organic texture, having its vessels as well as the thicker parts of plants.

In many trees, especially those upon which the skin continues for a considerable time—such as the birch, the plum, and the cherry—the principal fibres are placed crosswise to those of the wood, or round the circumference, and accordingly it is much more easily torn or separated in that direction than in any other. In leaves and in herbaceous stems this structure is not so apparent.

The skin of a plant is to be regarded as an original component part of it, being found in the earliest stages of the embryo, and accompanying every development, whether that be stem, bud, leaf, flower, fruit, or seed; but there is in the other parts of the tree a power of reproducing skin when it is partially destroyed. If, however, the part from which the skin is taken be exposed to the air, the reproduction is slow, and in the manner in which it takes place one important use of the skin is displayed. If the wound is not made entirely through the bark a portion of the bark champs, turns dark, and festers; in time that portion separates, and there is found to be a new skin below. If the wound is made quite down to the wood, the cellular texture of a portion of that dries, the vessels open, and it has the appearance of being dead. Even then, however, the wound heals; but the healing comes from the sides of the bark, a portion of which in all cases decays and scales off, and new bark and skin, with a layer of wood, gradually advance till the wound be closed; but in these cases it is a long time ere the scar be obliterated. If, however, the wound be covered up from the air, an epidermis forms on living bark, or bark on living wood, without issuing from the parts that still remain upon the plant. Thus the skin is the only part of a plant that can, in the living state, bear exposure to the air; and if by any means it be destroyed, a portion of the remainder must die as a protection to the rest. Hence, in trees that have the skin entire, the bark is living throughout its whole structure; but when the skin is destroyed, the bark champs and scales off in a dead state.

Even the external surface of the skin is not a mere membranous expansion, but has its vessels and appendages. There are pores, hairs of various kinds, and follicles or glands, which are supposed to secrete or prepare various matters.

The pores of the skin are very minute openings; they are of various shapes and sizes, and fewer or more numerous according to the nature of the plant; but they are always very minute, and in some plants there are many a million in the square inch. They are most abundant in the leaves of those plants in which they are found; and they are wanting in the cellular plants, in all plants and parts of plants that are under water, and in those internal surfaces of leaves that are not exposed to the air. In the root they never occur; and they are generally wanting in those succulent plants that bear the dry season in the tropical climates. They are, also, few or wanting in those plants, such as the houseleek, which grow in dry places, and yet are remarkable for the succulent character of their leaves. In cases where the pores are few or wanting the skin is much firmer and thicker than in the species that have numerous pores. In flowers, the calix, or cup, under the petals or floral leaves, generally has pores, but the petals themselves are without. Fleshy fruits seldom have them, and they are never found in the coats of seeds. The upper sides of leaves are often destitute of them, though they are found on the under sides. Those plants that can live either in the air or under water have the character of their leaves changed if transferred from the one to the other. This is very conspicuous in the common green mint; if that is made to grow under water there is not a pore in the leaves; but if it is raised into the air the leaves of the part so raised drop off, and leaves having pores supply their places. A contrary change takes place if it is brought out of the air and placed in water. Light seems as essential to the existence of pores as atmospheric air; for plants that grow in the dark have none, and those that are supplied by artificial light have few, even if they are the same species that would have them in abundance if growing in the air and light.

The pore, therefore, though it exists in the cuticle, is not to be considered as an original or essential production of that tissue, but rather as a production of air and light, or of that action which they excite in the plant. It is probable that these pores sometimes absorb, and sometimes give out matter by evaporation, but whether both these functions be performed by the same pore, or by pores of different kinds, has not been ascertained; the fact that the pores can so absorb as to refresh and invigorate the whole plant is well known to every one who has (as who has not?) noticed the effects of a shower, not one drop of which could have reached the roots. The fact of the evaporation is also clearly established by the coldness of growing leaves as compared with the rays of the sun, and even with the atmosphere, in a hot day, and also by the flaccid and languid appearance which they put on in hot dry weather. There are few plants in which the difference of temperature in the active leaf and the leaf not in action is better seen than in the common laurel. The old leaves of that plant do not fall off or even change their colour immediately upon the young ones being produced; they die slowly; but while they are yet green it may easily be perceived that there is no action in them. They acquire nearly the same temperature as the direct rays of the sun, while the young and growing leaves remain quite cold; of course there is no evaporation going on at their surfaces. In the autumn, when the leaves generally begin to decay, a similar change takes place, though not, perhaps, to the same extent, and it is not so striking as there are no young leaves upon the same plant wherewith to contrast it.

The follicles, or glands, that are found on the surface of plants, are a part of the subject that requires to be treated with great caution, because they have little resemblance to the varied organs in the animal system to which the name of glands is given. The places of vegetables on which glands are situated are juicy stems, leaves, flowers, and fruits; and they secrete various gums, honeys, sugars, oils, and other substances, which are the causes of much of the odour of vegetables, and which are often produced in such quantity as to be visible to the eye. The organs themselves are, however, very minute; their structure is difficult to be explained, and their functions more so; and thus any statement that professes to treat of them systematically must be received with the utmost caution.

The only other appendages to the skin of plants (though many, if not all of them, come from the structures within the skin) are hairs and prickles: they are chiefly found on the same kind of surfaces as the glands or follicles, namely, on leaves, on succulent stems, and on fruits. They are often hollow; sometimes they consist of a series of cells placed end to end; and in many instances they discharge peculiar fluids or juices. The chief difference between a hair and a prickle consists in the greater thickness and rigidity of the latter, for both of them have their origin in the skin or bark; and whatever may be their texture they never contain any woody matter, properly so called. In that respect they differ from thorns, which always have their origin in the wood, and may be considered as a kind of abortive branches. The prickles of some plants are perforated, and have at their bases a sac or vesicle containing an acrid liquor, which may be forced out by pressure upon the point, the whole apparatus having some similarity in structure to the poison-fangs and poison-bags of serpents. The common stinging-nettle *(urtica dioica)* is an instance of that structure; and many of the tree-nettles, as, for instance, the *urtica gigas* of Australia, are much more virulent, and seem to have their virus upon the surface of the bark, in the state of a powder, which stings without any apparent wound. The common nettle does not produce inflammation unless the prickles actually penetrate the skin, and even then the inflammation is local; but the effect produced by a local touch of some of the tree-nettles extends over the whole body, causing a very unpleasant general eruption. The prickle of the nettle is stiff, but the sac, upon which it is inserted, gives it a flexibility at the root which makes it sting differently when differently touched.

SECTION III.—MEMBERS OF PLANTS.

The separate members of plants of which it is necessary to know the anatomical structure, before the economy of the plants themselves can be rightly understood, are, principally, the root, the stem or trunk, the branches that divide off from that, the appendages, such as thorns and tendrils; the buds, the leaves, the flowers, the fruit, and the seeds. The principal structures of which most of these are composed being already noticed, it remains only to give some account of those differences in their forms, and the arrangements of their parts, upon which differences in the habits and characters of the plants depend.

Roots.

Though it may be said that every plant growing on the earth has a root, yet there are many aquatic plants that have none; and there are some plants that grow in very dry places of which the roots are to be considered as little else than holdfasts, by means of which the plants are retained in their places. Roots that do perform the function of drawing nourishment to the plant are named from their forms, and also from their duration. The roots of trees and shrubs are, generally speaking, *branched* in their form, and *perennial*, or lasting for more than two years. When the plant has a number of roots nearly equal in size it is said to be *fasciculate;* or if the parts be slender it is *fibrous.* If the parts be arranged edgewise, in the form of a hand, the root is called *palmate;* if it consists of thick knots, as in the potatoe, it is called *tuberous;* and if it form a thick swelling of fleshy or cellular matter, whether that be solid as in the turnip, formed of coats as in the onion, or of scales as in the lily, it is called *bulbous.* If a root be long, and thicker at the middle than at the ends, it is said to be spindle-shaped or *fusiform;* and if the under part of it terminate abruptly as if it were bitten, it is said to be *præmorse.* When it consists of many joints or pieces it is called *articulate;* and when it runs horizontally below the surface it is said to be *creeping.* There are other distinctions, but those that have been mentioned are the principal; and, making allowance for differences of form, they may be said to include all the others. In respect of structure, every root may be considered as woody, or fleshy, or fibrous.

A root which lasts longer than a year, and has wintered, may be considered as consisting of two distinct parts,—the *body of the root*, and the *rootlets*, or *radicles.* These last are understood to be annual productions, and to be the only parts by which the root increases in length under ground, just in the same manner as the shoots or twigs are the only parts in which it increases in length above ground. In the branched root, the *radicle* of one season becomes a young branch the next; and then, though it increases in thickness every succeeding year, it lengthens no more. The structure of those roots being nearly the same as that of the stem and branches, their action must be similar, and old roots, as well as old stems, must, in time, become too hard for performing any action at all. When a root becomes very long and hard, it performs its functions imperfectly, and the tree languishes; but it may be restored to health by shortening the roots. Sometimes, too, more especially in those trees that are much disposed to send up suckers from the roots, the action of the tree takes that direction; and, while the roots run over a great breadth, the tree hardly produces any wood. The cure, or at least the palliation, in that case also, consists in shortening the roots, and partially laying them bare during the cold season.

Those trees which are most disposed to form buds in the bark, as well as at the ends of the twigs, are also the most disposed to throw out suckers from the roots; and the vessels of such roots are commonly more twisted and convoluted than those of the others. The deciduous cypress *(taxodium disticha)*, though belonging to the same natural family with the common fir *(pines sylvestris)* which never produces a sucker or a bud, has a very singular habit in the roots. Large lumps of woody matter are formed, rising above the surface of the ground, which, at a distance, have the appearance of stones. The roots of herbaceous plants vary very much, but, in general, their cellular and vascular structures are blended together.

The radicles, or rootlets, have been mentioned as annual productions; and, if it be placed in circumstances favourable to their growth, they can be produced from any part of the plant that can *originate* a lateral growth. If the part be capable of forming a bud, and thence a shoot, and ultimately a branch in the air, it will form a rootlet, and thence a root, if it be placed in the earth and have the degree of heat and moisture that are requisite. The knots or joints of herbaceous stems, and any young twig of those trees that form buds indiscriminately on any part of the surface, may be made to put out roots; but those plants that never make any but terminal buds, cannot be made to form a second root. The knowledge of those properties is of great use in the culture of plants.

In this we have a remarkable instance of how far plants depend upon, or can be altered by, circumstances. No art, how skilfully soever it may be applied, can change the budless plant into a budding one, any more than art can produce a plant without a seed or grain containing vegetable life. But, if the quality exists in the plant, that quality can be modified so as to become a root in the earth, or a branch in the air. If the former, it produces only rootlets and fresh roots; and if the latter, it produces leaves, flowers, and fruit. In the former case, though there are vessels for the absorption of moisture, or whatever else the plant may draw for its support from the soil, yet there are no pores adapted to the action of the air, or to what we may perhaps consider as the respiration of the plant; while, in the latter case, these are never wholly wanting. That the plant is that particular species, and not another, seems, therefore, to depend on itself, or if it is to be greatly changed it must be done through successive generations; while the circumstances regulate what the product of the local action shall be, whether a root, a stem, a leaf, or a flower. Thus a most ample scope is given to the art of the cultivator, at the same time that there appears to be a limit which cultivation cannot under any circumstances pass.

Stems.

The stems of plants vary as much in character as the roots; but it will not be necessary to mention more than one division of them—the division into stems and trunks,—the former belonging to endogenous plants, and generally to all herbaceous plants, and the latter to trees and shrubs. When, however, the stem bears only flowers and not leaves, it is called a stalk, or scape *(scapus)*, and when it is of the character peculiar to the grasses, it is called a straw, or culm *(culmus)*. With the exception of the trunks of trees and shrubs, no stem is destined to receive any accession in thickness beyond its first growth if endogenous, or its first year's growth if herbaceous; and, therefore, there is no such separation of parts as is found in the trunk of a tree. As the stem rises, the part that has been formed ceases to receive any new accession of matter, and thus may be said to have no action of its own, but merely to serve as a support and as a means of communication between the root and the part where vegetation is still elaborating new matter. The action, however, is not the same during the whole of the annual growth; for if the season has been unfavourable at the commencement, and favourable afterwards, the subsequent part of the stem will be thickest; and, under opposite circumstances, the effect will be reversed. When a stem of this kind has been once completed to a given section, there is no external action to compress it, and no internal action to increase it; and, therefore, it records, in its varied diameters, the state of vegetation during the season of its growth.

A similar obedience to circumstances is often found in the trunks of trees. The relative lengths, from knot to knot, render the pine a sort of chronicle of the seasons for the period of its growth, though it must be borne in mind that the annual growths of such a tree are always greatest near the middle of its length. Other circumstances than the seasons have similar effects. A plum-tree, trained on a wall, in rather an unfavourable aspect, was allowed to run to head over the wall by the central shoot. In the course of two years, that shoot, which was a mere twig at the first, had acquired a greater circumference than the trunk below the lateral branches, though three or four of these, on each side, still remained trained to the wall: the over-topping part of the tree had a much better exposure to the weather, and that accounted for its superior vigour. From this it is evident that the effect is greatest in the immediate locality of the increased vegetable power, even when the tree is every where of the same species. In grafted trees, where, for the sake of earlier or more abundant fruiting, or longer duration, the scion is put on a slow-growing stock, we often find the portion of the stem, belonging to the scion, swell out to several times the diameter of that of the stock; but it seems that rigidity, arising from the slow growth of a part of the tree, has the same effect. It would appear, too, that this effect is the more striking in the closer-wooded trees, that have the smallest portion of cellular tissue in their mature wood, and the most minute vessels.

Branches.

A branch varies in nothing but size and position from the trunk out of which it springs. The branch, originating from a bud, may be considered as one year younger than the preceding annual layer of wood in the trunk, or other branches from which it originates; and thus, as the branches become more and more ramified, the number of annual growths in them becomes less and less. It by no means follows, however, that the quantity of wood in all the branches is less at any section than that in the trunk. It has been found, by actual measurement, to be sometimes a fourth more; and, if the tree is healthy, there is reason to believe that the section of all the branches is always greater than that of the trunk, upon the same principle that young trees increase faster than old ones. But the same circumstance which makes the trunk increase more slowly than the branches, makes it better and more compact timber; and makes the *root cut* before any branch sets off better timber than those after. Unless in very particular cases, where a branch appears to be formed from a woody ganglion, which will remain forming a knot in the bark for several years before it forms a bud, the branch may be considered as carrying with it a portion of the fasciculi of vessels; and there are fewer above the insertion than below, and consequently the wood is of closer texture.

The branches of the common fir offer a favourable instance for examining the structure, and also for judging of the development and decay, of those parts of the tree. The mode of extension there is by a central bud at the end of the top shoot, surrounded by lateral ones. They are produced at the same time, and thus, as long as the whole continue growing, they must contain the same number of rings both of bark and of wood. Their dimensions are, however, very different; the centre bud, while the leaves are yet wholly enclosed by the spatha and the scales of the hybernaculum, is often ten times the length of those that surround it; and it will acquire a diameter of a foot, while that of the largest surrounding branch is not an inch. If the tree grows in a close forest, so that the branches have not free exposure to the air and light, their action becomes weak, and they are strangulated by the increasing wood of the trunk. When their action begins to fail they produce wood of a far greater hardness than the rest of the tree, as carpenters find in white deal, which is the wood of rapidly-growing pines. In all cases, that portion of the branch of a pine which is cased up in the subsequently formed wood of the tree, is much more hard and durable, and contains much more turpentine, than the wood that has grown without any interruption; and that it is the interruption and consequent pressure on the vessels, and not the circumstance of being a branch, that is the cause, is proved by the fact, that the contorted rings of wood, which surround the branch, partake of the same indurated and resinous character; which character diminishes, as they recede further from the remains of the branch, and assume more of a straight form. If the branches are destroyed at an early period of their growth, the vessels of the tree are often able to overcome their resistance and obliterate their structure. There are many instances of planks, twenty or thirty feet in length, without the least vestige of a branch in them; and yet we know that a foot or a foot and a half is the average distance, at which branches must have been produced.

Some writers, on the structure of timber (Hill, for instance) have assigned a sort of vitality or permanent branch-producing power to that ring of the wood which immediately surrounds the pith; but that cannot be true, as hollow trees produce abundance of branches at the outside, when the cavity within is the size of a small room, and thus, where, probably, more than a hundred rings of vessels in the centre, pith and all, are completely gone. Whether the branch spring from a terminal bud, or from one formed in the bark, it will always be found that it takes its origin from the living part of the tree; and that, while both are alive and vigorous, it penetrates just as many rings into the trunk or larger branch, as itself contains rings, and no more. In pines it is true that this will always reach the pith, because the elongation and the branch are in bud and developed the same season; but in trees that form cortical buds, whether by a convoluted woody ganglion or not, the case is otherwise. When there is a ganglion in the case, the branch must be dated from the first formation of that, which may be some years previous to the appearance of any leaf or shoot: but though the ganglion may appear to be imbedded in the vital or active part of the tree, yet one or more fasciculi of vessels may always be traced, connecting it with the wood of the year in which it was first formed.

When a branch sets off from a stem that is hollow, or to become hollow by the drying up of the pith, it is always at a joint, or *node*, where there remains a diaphragm or partition after the hollow is formed.

If the growth of the plant is partially checked, substances accumulate, which we may suppose would otherwise be part of its general structure, or of that portion of it that may not be fully developed. Thus there often forms at the joints of the straw in stunted oats a quantity of saccharine matter, which is not found in strong-growing plants; and the same may be said of many of the grasses,—the small hard grasses that grow upon dry grounds, always being sweeter than the large and succulent ones that grow upon moist; and the creeping roots that remain in the earth, when every leaf is burnt up, are often very sugary. In some of the reeds, too, the matter that goes to the epidermis is sometimes found accumulated at the joints;—the bamboo, in particular, forms concretions of silicious matter, combined with a little lime and vegetable substance, to which the name of *tabasheer* is given in India.

In all trees that can form cortical buds, the formation of these may be very much increased by artificial treatment; and in many places, more especially in the vicinity of London, this property is taken advantage of for the purpose of converting the trunk of a growing tree into a sort of unnatural coppice for the periodical supply of brush-wood. Trees treated in this manner are called *pollards*, because the heads of them are trimmed or *polled*. In a grove that mode of treatment would not succeed, as the trees, not having access to the weather lower down, would die, if denuded of so much of the top foliage; but in hedge-rows, they succeed to a very high degree of—deformity. The top is reduced to about the size of a rook's nest, and as that does not contain a sufficient number of leaves for the purposes of vegetation, the trunk pushes out lateral shoots, and these thrive better than the small portion of the natural head, which is reduced to the state of that of a tree in an advanced stage of natural decay. The heading down of fruit-trees, after their natural branches have become cankered, either for the purpose of grafting or for the pushing out of new shoots, depends on the same property;—and no tree that has not the power of putting out cortical buds, can renew its head, either by a natural evolution or by grafting.

Appendages.

The appendages that may be considered as emanating from the wood of trees, or from the substance within the skin or the bark, may be classed as thorns, as claspers or holdfasts, or as tendrils.

Thorns originate from the very same part of the tree as those cortical buds that produce branches; they are never found on the stems or branches of trees that are incapable of producing such buds; they are produced only on trees that have very hard wood, and grow slowly; and their number diminishes with cultivation; consequently they may be regarded as the offspring of abortive buds, which have not sufficient vegetable action for pushing into branches. Though it is not absolutely made out, what wild plants are the parent-stocks out of which our garden, or rather orchard, fruits have been cultivated, yet it is true, as stated by authors, that those trees that have the closest resemblance to them are armed with thorns. We have also converse proof: it is stated that the *stipulæ* or membranous appendages at the insertions of some leaves, the *petioles* or foot-stalks of some leaves, the lobes of leaves, as in the date-palm, and the *peduncles*, or stalks of some flowers, occasionally change into thorns. In many plants, as for instance the gooseberry and berberry, thorns occupy the places which in other plants are occupied by stipulæ; in many species of holly, thorns are formed round the margins of the leaves, and in some there are rows upon the upper surface; and these are connected with the vascular part of the leaf, and are consequently thorns and not prickles. When the bark is removed by maceration in water, or by any other means, hairs or prickles are removed along with it, but thorns are left.

Holdfasts and tendrils. The use of these organs is either to support the plant or to obtain nourishment for it; and they assume different appearances according to the functions that they have to perform. They are thus not mere appendages to the skin or bark of the plant, but organs originating in the general structure, and, like all the other active parts of vegetables, adapting themselves to circumstances.

The ivy is one of the most familiar, and, probably, at the same time, one of the most striking instances of this adaptation. When a plant of ivy is so situated as that the air comes with equal freedom to it on all sides, the stem acquires the habit of an ordinary tree or shrub, and puts out nothing but leaves, twigs, and flowers. The leaves, too, put on nearly the form of those of the laurel; so that one who had seen ivy only as a climbing plant, would, with difficulty, recognize it in its independent state. If, however, the one side of the stem be near a wall, or any other shelter or support, the leaves retain the lobed shape, and little claws or roots *(claviculi)* form on the stem. These are covered with smaller filaments or lines, and furnish a viscid juice by which they glue themselves to the support, and penetrate the fissures and crevices, if there happen to be any. The embrace of the ivy is so close that it can stop the action of a tree, even although its original connexion with the ground be divided. As the tendency in the stem to put out claws, is always accompanied with that of the leaf to form five parts, and also in the stems to run more in length than increase in diameter; and as those characters disappear together, it shows that their presence or absence is the result of a modification of the general action of the plant, induced by the circumstances in which it is placed. There are, among the parasitical plants, many modifications of this form of fastening; but the greater part of them conduce to the same end.

The tendril, like the holdfast, consists of all the common tissues of the plant, and is considered as a changed leaf. It is produced at the junction of two leaves, where, under other circumstances, a continuation of the twig might be expected; or it occupies the extremity of a pinnated leaf, where, under other circumstances, we might look for a terminal leafet. In both cases it has the power of very considerable extension, and it sometimes branches into two parts; there are some cases, too, in which it is formed from the peduncle or even the petal of a flower; and there are particular cases in which, instead of a spiral clasper, the tendril changes to a holdfast something like that of the ivy.

Those appendages to the general structure of plants, are of value to the student of the natural history of vegetables, chiefly as they show how far the characters of vegetables are dependent upon circumstances; and how, in accommodating itself to those circumstances, a plant may change both the forms and the functions of its organs.

Buds.

Buds are not only among the most interesting parts of plants, but among the most wonderful of all the productions of nature. They are at one and the same time parts and wholes. They are portions of the plants upon which they are produced, considered as one individual of the vegetable race; and they are new vegetables, which may be made to grow and flourish apart from the plants on which they are produced; but still they have an accordance with the parent-plant, more close and certain than is to be found by any of the other modes by which plants are propagated. At the same time the plant which is produced from a bud has a subordinate character; and in its habit resembles a branch more than an entire tree. Still, it is to buds that we owe much of the beauty and usefulness of vegetables. The spring, when they begin to expand those cases in which they were protected against the winter, and when the genial shower of the early morning seems to have powdered the hedges, and coppices, and groves, with emeralds and pearls, is the season when all feel renovated; and the chief pride of the year is the expanding and progress from the bud to the flower and the fruit.

Gaetner, to whom the science is indebted *(De fructibus et semenibus plantarum)* for very accurate and valuable information upon this branch, defines a bud as being an organic substance, sprouting from the surface of a plant, distinct at its first appearance from the proper and permanent parts of the plant, but gradually becoming a permanent part, if it remain, or capable of becoming a plant of the same kind, if separated and placed under proper circumstances.

In the present state of our knowledge, that definition is not absolutely universal; for we believe that the circumstances under which the bud of a fir, or of several other plants, can be converted into an independent plant, have not been found, although that does not warrant us in coming to the conclusion that they are not findable. To maintain that art cannot do, in the case of the growth of plants, all that can be done by nature, after *all* the circumstances under which nature acts are known, is not a very encouraging or a very philosophical doctrine. That the crown bud of a pine-apple should not only grow very readily into a perfect plant, but that it should grow nothing the more for being left some time to dry, is as wonderful as the growth of any bud whatsoever. In these plants we have the leaves first changed into the fruit; and after that fruit has been matured we have the leaves again in the crown bud; and there are instances in which the separate scales of the fruit become each a little fruit with its crown bud, similar to the single one that is usually produced. If we take that plant, we have a succession of changes, from leaves to fruit, and from fruit again to leaves,—on what may be considered as a continuation of the same stem.

The buds of plants vary in their appearance, nature, and economy, not only with the different species of plants of which they are the buds, but with the parts of the plants on which they are produced. In what we are accustomed to call the more perfect plants, that is, in those that are phenogamous, or in which we can see a distinct system for the production of seeds, independently of that which produces buds, or otherwise enlarges the parent structure, there is not much danger of confounding a bud and a seed; but in some of the cryptogamous plants, the distinction is not so easy; and hence what one has called a bud, another has called a seed, and a third has used some name that may be considered as meaning both or neither. But whatever name be given to that from which a cryptogamous plant is evolved, there is this marked difference between it and every bud, and also the seeds of those plants that have visible flowers:—in the phenogamous germen, whether that be seed or bud, there is always a visible centre of vitality which has a specific locality, so decided as even to form a character of many orders of plants. Those who are acquainted with the seed are able, though that seed be quite spherical, to point out the very spot from which the young plant will spring; and if it be a bud, they can tell the point at which the shoot will issue, and what will be its direction. There is also a specific locality for the seed or the bud, and if it be not in that, we need not seek it upon the plant. With the cryptogamous plants it is different; the germ of life in their *sporules* does not appear to be allocated, but may spring from any part. Indeed, as we cannot with strict propriety say that any plant that does not flower has seeds, so neither can we say that it can have buds. Thus, when we speak of buds properly so called, we mean those of flowering plants.

If, however, both the great divisions of plants be included, and nothing that is not preceded by a flower is to be considered as a seed, then there are two distinct buds belonging to the cryptogamous and two to the flowering plants, and in each of these there are many modifications.

1. The simplest form is that to which Gærtner gave the name of *propago*, and which has been called by many other names. It is a simple, leafless body, variously formed, sometimes entirely naked, and at other times covered with a bark-like case. It propagates exactly like a seed, only that it is not preceded by a flower or any perceptible fertilizing

or fertilizable organs; and it has no distinction of embryo and food for that embryo, as there always is in the seeds of flowering plants. It is often exceedingly minute, and in some plants it can barely, if at all, be traced. In ferns those bodies are contained in capsules on the barks of the fronds or leaves. In mosses it is often contained in an organization that might be mistaken for a flower, and then a seed-vessel; but no fertilizing organs are apparent; the embryo is wanting; and therefore it wants the proper characteristics of a seed. Those propagines, in the more minute plants to which they belong, appear to be very generally diffused; they seem to be secure from time and from all accidents, except actual combustion (for they are so small that they can hardly be crushed); that the plants spring up wherever the circumstances are fitted for them; and therefore it was a very old prejudice that those plants were produced spontaneously out of other substances, without any germs.

2. The other form of the buds of those plants is the *gongylus*, which is generally round or oval. Like the former it is produced without flower, and has no germ localized; but, unlike the other, it is produced within the substance of the parent-plant, and is not shed spontaneously, neither does it vegetate, until the part in which it was produced is in a state of decomposition, and serves for a sort of soil to it. It is to be found in lichens and mushrooms.

3. The third kind is a bulb *(bulbus)* which is sometimes produced above ground, but in more

instances below. But even when in the ground it is always on the stem part of the plant, that is above the collunal plate, which separates the rootlet-bearing part from that which originates leaves. It is sometimes solid, sometimes scaly, and sometimes formed of concentric coats or tunics. There is always an allocated embryo in it, ready to spring up under favourable circumstances; and the plants, upon which it is found, flower, although the flowers of some of them are followed by bulbs and not by seeds. Perhaps the tubers of the potatoe and other similar plants ought to be considered as belonging to this class, for they are produced above the part of the parent-plant that yields roots, properly so called. The strings on which they are found may, in their early stages, be raised above the surface and become stems, and if the branches above ground be earthed up in their early state they may be made to produce tubers.

All the three kinds of buds that have been mentioned produce new plants; and those of the third kind are successors to the plants by which they are produced; which also is, in so far, the case with the second kind. They are natural methods of propagation, and plants may be continued from year to year by means of bulbs in situations where they do not flower, or at least ripen seeds. Many of the early potatoes, which are varieties produced by cultivation, do not even flower, and yet they are very easily and successfully propagated by the tubers. In these tubers, too, there are local germs in what are called the *eyes (oculi)*. These put out leaves before they put out any roots; and those who are fond of taking the theory that one form or organ in a vegetable is another organ changed, may easily imagine that the whole of an above-ground plant is condensed into each tuber, and that the plant, had it taken the other direction, would have had as many branches as that tuber has eyes.

4. The fourth kind is what is called a germ *(gemma)*; and, unless it be through the medium of flowers and seeds, it never directly and spontaneously produces a new plant; sometimes, indeed, as in the Scotch fir, it cannot be made to produce a separate plant in any way but through the process of fructification; but in many plants it can. When it is on the root, and sends a shoot up through the ground, the root can in general be parted after a time; and often a very small piece of the root will suffice, as in the case of "pipings" of pinks. In other cases it can be applied to another living tree, of the same natural order, but in those cases a portion of the inner bark around the base of the bud must be applied to the surface of the wood of the tree, and the junction held together and protected from the air for a time.

The proper buds, that are formed on the stems and branches of trees, vary very much in their portions, their forms, and their uses or destinations. In most trees they are placed in the axils of the leaves, that is, in the angle which the petiole of the leaf forms with the twig toward the termination of the latter, without there being any immediate connexion between the leaf and the bud; for there is generally, when the leaf falls off, a little ridge of entire bark, between the bud and the cicatrix. In the pine the buds are always at the extremities of the twigs, one terminal, and other and generally smaller ones surrounding. In all trees, there is a terminal bud; but it is only in those that have two lateral buds exactly opposite to each other, and thus are three-forked at every branching, that the terminal bud is accompanied by others, except in the case of all the buds being terminal. When there are three buds together they are in the same plane, and the next three that are put out by the growth of the middle one very generally have their planes at right angles to that of the former three. In some cases, however, the deviation from the former plane is not so much as a right angle, and the two rows of buds and branches on them form a double spiral round the stem. When there is but one lateral bud at each formation, the twig terminates in a single bud; and the other buds are alternate on the sides opposite to each other, or they wind round the branch or stem in a single spiral. They are formed very early; but they are at first mere points; and upon each tree they have a peculiar form, and their axes form a peculiar angle with the part on which they are originated, which forms an obvious character of the tree, though there are departures from it in particular instances. Generally speaking, the buds of hard-timbered trees come off more at right angles than those of trees in which the wood is softer; and a greater or smaller number of them produce woody thorns, according as the tree is in a more exposed or more sheltered situation; but these characters are not universal. All the buds of this description are formed in the season before they produce leaves or flowers; but they are found only on perennial stems: the buds, if they may be so called, on an annual stem, at once expand and complete their vegetable action in the same season, though often at different periods of it; and when the root lasts longer than a year, the new buds are found upon that, sometimes in the autumn, and sometimes not till the spring.

It is chiefly where the seasons are well marked, and there is a considerable interval between the foliage of one year and that of another, that buds have the decided character that has been mentioned. Where the growth is constant or nearly so, there are no buds; and the twig is terminated, and the lateral branchings break out at once, in leaves. Even there, however, there are periods of greater growth and repose; and the commencements of the vigorous growths are generally marked by the branchings. It seems to be the climate, however, rather than any thing peculiar in the tree itself, which produces this change, and whether it be branch or flower, that appears without a visible bud as its harbinger, budding or germification is still to be considered as the mode in which it ramifies into branches and produces its flowers.

The entire bud, when, from the circumstance of climate or the habit of the plant (for there are some plants which thus bud in tropical countries, and some in the cold countries that do not) it remains for some time unexpanded, consists of two parts,—an external one, called the *hybernaculum*, or winter case, and an inner one, which is the *germ* or really living part of the bud. The hybernaculum consists of a number of scales, varying with almost every variation of plants. The external ones are tough, impervious to water, and probably to air; and they are very imperfect conductors of heat. The inner ones are more succulent, from an accumulation of vegetable matter in them not unlike the cotyledons or other receptacles of the albuminous or farinaceous matter in seeds. This matter answers the same purpose as that in the seeds—the nourishment of the part destined for growth, and it is by the action of attracted moisture through the twig (for it comes not through the outer scales) that the bud expands, and the substance of the inner scales softens and passes into the vessels of the gem. It is this store, in the inner scales of the hybernaculum, and not the germ or vital part, that is sought after by birds when seeds cease to be found; and it is not settled whether, in ordinary seasons, the birds do more harm or good to trees. Perhaps the good preponderates. They seldom cut off the terminal buds either of the main stem or the branches, because they cannot so well rest upon the very extremities of the twigs. Thus what they do tends to the height and lateral expansion, and also to the letting in of air among the ramifications of the tree, —a circumstance of the utmost importance to vigorous growth. The buds from the sides of the branches, whether they are to produce new twigs or fruit, are always many more than the tree can bring to maturity; or if it could, in the case of the branch buds, the top would soon get so matted that not a beam of light and hardly a breeze of air could pass through it; and thus the whole of the interior would be inert and useless to the purposes of growth, and the annual increase of the tree would actually be less than if the twigs were only half the number. It is, therefore, extremely probable that, in average seasons, the birds are not spoilers but useful pruners; and what they take away may, farther than this, contribute to the preservation of the rest. If the action is so weak that the buds languish and do not put forth their green leaves, but have mere points yellow or pale from the want of a due stimulus of sap—a state of things which is a necessary consequence of more buds than the tree can put into action, the substance of the bud does not acquire that austerity, from acids and alkalis, which is the plate and mail of young vegetable life. In consequence, it becomes at once the hatching-place and the prey of numbers of insect larva, which would not be produced, and certainly could not subsist, upon a vigorous vegetation. It will be seen in the next chapter that flowers have, on sunny days, the means of producing a considerable elevation of temperature; and from the very cause, at least, one of the causes why they do so, a flower that has not the proper supply of sap must make more change than a vigorous one. Thus there may be heat to hatch the egg of an insect in the flower, while there is not so much as would effect that purpose in the leaf; and it must be more easily done in a sickly flower than a vigorous one. In this way the flowers of fruit-trees are often "wormed," while the leaves escape; and every one must have observed that, in the more advanced part of the season, the caterpillars of moths strip first, and most completely, those trees of which the leaves are sickly and therefore sweet. A chill coming suddenly upon a tree has nearly the same effect as a superabundance of buds; and upon that principle the "insect breeze"—the cold dry wind from the east, or from any other quarter that is adapted to send cold dry winds to the place—which is vulgarly supposed to rain caterpillars upon the leaves—subjects ill-adapted for riding on the wind, even after they are winged as moths—may be very easily understood. It is the same cause which produces—no, not produces, but affords circumstances favourable for the production of, all the small cryptogamous plants that infest the leaves and bark of the useful vegetables,—the smuts, the ergots, the rusts, the moulds, and all the other similar pests to the cultivator, which can be shown to be, not merely a disease in the substance of the plant, but a growth of other plants for the small germs of which that disease has afforded a proper soil. Those who are fond of yoking all sorts of ill-matched things into the tandem of Cause and Effect, sometimes attribute these pests to particular plants, as for instance, to the barberry; but it may be depended upon, that a scare-crow set up in the vicinity, formed of an old doublet and wig, and without any cross-stick to extend the sleeves of the former, will completely counteract the most malignant barberry-bush. It would not be amiss, however, if those who dream about those matters should awaken, and consider the effects of the alternation of ploughed fields, and crops of succulent herbage, such as clover, lucern, and the smaller legumes in "slacking the thirsty breeze." This is rather a digression; but it may tend to open up some useful views which any one who is conversant with fields may follow out.

The germ, or living part of the bud, is at first a mere vesicle or watery vessel, but it soon appears made up of one or more leaves folded and curled together, the mid-rib of the larger one, which is then the only vascular part of the germ, being formed something like a keel *(carina)*. The other and softer part, which is merely the lobes or parenchymous part of the first leaf, together with the younger leaves, has been called *medulla*. The appellation is not a very correct one, inasmuch as it is not marrow; and further as it has reference to the old theory, that the pith, the use of which ceases sooner than that of any part of the tree, is the origin of all vegetation. That there is pith in the young shoot is true, but that pith is elaborated by the action of the shoot itself, and does not make its appearance till the wood and bark can also be distinguished. In many plants there is even a sort of a separation between the pith of the shoot and that of the bud. The original source from which the bud comes is the vessels of the young wood in the shoot, and from these also comes the store of nourishment that is laid up in the hybernaculum; nor does the bud exercise any *returning action* till it has expanded into leaves. Thus the vessels or wood in the production of the bud consist, during all their existence, of one ring or layer less than the former year's part on which they are produced; and when a tree has run to a certain height, say eighty feet, by eighty years of successive seasonal shooting from terminal buds, the trunk of it will consist of eighty hollow cones, the outside one reaching to the top, and all the others shorter by one year's growth, than the one by which they were followed in the course of growing.

Leaves.

Perhaps leaves are the most interesting things in nature, and certainly of visible living productions they are the most numerous; they are the "productive labourers" in forest and in field; and but for their action we could neither have timber nor corn. They are the shade, the shelter, and the ornament during the active season of vegetation; and, besides their elaboration of vegetable matter, they perform many important functions in nature's general economy. The air, which stagnates and gets impregnated with poisonous vapour over the dreary sand of the desert, is put into motion and activity by them; the soil, which, when naked, is burnt up by drought, is kept in a comparatively humid state where there are leaves; the summer day, which upon the dry and naked sand or rock would be intolerable, is rendered cool and refreshing by them; and the earth, which, if bleak and naked, would be frozen deep in the winter, is kept at a comparatively high temperature by its vegetable clothing. On those sultry days when there is not an air stirring on the open fields, there comes always a gentle breeze from the forest; and those who have been panting over the park or the wild, feel equally pleased and refreshed by the soft wind which fans them whenever they get under the shade of a great leafy tree. How much sooner one gets cooled and refreshed there than under the shade or even in the interior of buildings: and how delightfully the air plays through the opposite windows or doors, if the house stands on the margin of a wood with an expansive lawn before it. In all these and countless operations that give pleasure, and make us feel the force of Cowper's workmanship of "God" in the country, and of "man" townward, the leaves are merely performing their own vegetable functions; and we have this certain confidence, that the more we are delighted with the progress of their labours, the more shall we be enriched by the result. The enchanting summer, when all is fresh, and green, and vigorous about us—when the little winds stir without any perceived active spherical cause, and when perfumes come ever and anon upon us—wafted we know not whence, and mingled we know not how,—that, that is the time when the joy of hope comes most full upon us; and we never doubt that He, who makes the summer so delightful, will "crown the year with his bounty;" and that the wintry time will pass away in satisfaction and songs of thankfulness, until the returning sun call forth those glories anew.

The differences of leaves, and the names to which those differences have given rise, are so many, that the subject could bear to be treated as a separate science; and really it deserves to be so treated, as do also many other parts of the natural history of vegetables; for no little book can notice one hundredth of the mere parts, and no single book, how large soever, can embrace the whole.

One distinguishing character of leaves is the time of their duration. If they drop in the summer (not having stood the winter) they are called *caducous*, that is, falling, without any apparent cause in the change of the weather or temperature. If they remain till the autum, they are said to be *deciduous*, that is, cut off, because, in the change of temperature, we can see a sort of reason for their fall. If they stand over the winter they are called *persistent*, or standing; and if they continue for a longer period, they become *perennial*, in which state many of them, as in some of the *coniferæ* and other tribes, continue for many years,—that which was a comparatively weak leaf upon the young shoot, becoming an imbricated scale upon the stem or branch. The last is remarkably the case with the *araucaria imbricata*, represented in the vignette on the title, and to be described afterwards. Trees that have leaves of either of the first two classes are said to be *deciduous;* and those that have them of either of the last two are said to be *evergreen.* Each species varies a little in its time, both of expanding and shedding its leaves; but all deciduous trees produce their leaves in the spring, and lose them in the autumn; though in some, as in the beech on bleak situations, the withered leaves sometimes adhere till the young ones be expanded. The early and complete fall of the leaves is, however, just as certain a sign of health and vigour in the tree as their early and complete expansion; and if the leaves, after they are withered, remain firmly attached, it is just as certain a sign of death in that part of the tree to which they are attached, as if the buds were to remain unexpanded.

The progress and decay of the leaves of deciduous trees gives a very beautiful succession of colours to the seasons. When the young leaves come out of their hybernacula, their green is exceedingly transparent and delicate; when the full expansion has been obtained, it is rich and deep; then it becomes yellowish or russety; and ultimately passes into those rich autumnal tints which the landscape painter prizes so much; and which, contrasted with green meadows and grey stubble, and the deep blue and richly tinted clouds of an autumnal sky, is really very delightful, and not the less so by the necessarily suggested feeling that it is the season of plenty. Thomson and many others who embodied in their books their own thoughts and feelings, and not the thoughts of other men (which has nothing to do with feeling of any kind, and might be done by a millhorse, if you could put the requisite mechanical apparatus to him) always composed most vigorously and readily in the autumn; and if thoughts and enjoyments are the measures of time, autumn is really the longest quarter in the year.

Leaves stand on a footstalk which gets the name of the *petiole*, and if that be so short as that the base of the leaf appears to be in contact with the branch or twig, the leaf is called *sessile;* the same term has the same meaning as applied to flowers and to fruits. In their general form, leaves are *simple* when there is but one petiole, and one expansion, whatever may be the shape of the latter; and when the petiole is branched, they are *compound*. The different expansions of a compound leaf are called leafets; they are very varied in their forms and arrangements; but they are all generally in one plane; and a compound leaf, however composite its structure, may always be known from a bunch of simple leaves, by its insertion into the stem being by one petiole, and by that petiole being the only part that loosens when the leaf falls: the leafets of compound leaves never fall naturally—the whole separates from the plant in one mass. The place, the situation, the insertion, and the direction of leaves, all severally form external characters of plants.

The parts of a leaf, or of the leafet of a compound leaf, are,—the *mid-rib*, which springs from the petiole at the *base* of the leaf, and *terminates* at the *apex*, and generally, but not always, divides the expansion into two equal parts; the *riblets*, or little ribs *(costulæ)* that ramify from the mid-rib, and by their unions and separations form a net-work of vessels through the whole substance; the upper and under *sides;* and the *margin.* The places of the riblets, and often those of their minute ramifications, form furrows upon the upper side of the leaf, and ridges upon the under. These are sometimes called *veins,* or *nerves,* but the names are improper, as there are neither veins nor nerves in any plant. The mid-rib and riblets of a leaf belong to the woody texture of the plant; and the parenchyma that fills up the interstices is cellular, and generally contains the greater part of the juices.

The vessels are continued from those of the wood of the stem, through the petiole and all the ramifications of the riblets; and other vessels return in the same manner. The first set of vessels are, at least, many of them, spiral; the second set are not. The first set come from the wood, the last return to the bark. The connexion of either of those vessels with the cells in the parenchyma have not been noticed; but the substance that comes into the leaf passes, most probably, from the one set of vessels to the other by secretion. As might be expected, from their being parts of the same general organization, there is a considerable resemblance between the arrangement of the riblets in the leaf and the vessels in the wood. When the vessels of the leaf are straight, the wood has little adhesion laterally, and thus it is easily cleft. Plants that have their leaves of that description also very seldom form lateral buds; the lateral budding seems therefore to depend in a considerable degree upon the reticulated arrangement of the vessels in the wood, even though that reticulation be not anastomization, or a communication between the openings of the vessels, as it is in the arteries and veins of animals. Some pretty constant external characters may be founded upon the appearances of the leaves.

Flowers.

No words can heighten the interest of flowers; and thus we may at once notice their principal parts. A flower stands upon a *peduncle*, or flower-stalk, the upper part of which is expanded into a *receptacle*. Immediately upon the receptacle, generally a continuation of the same substance, is the *calyx*, or cup. That is usually more or less green, and it is not an essential part of the flower, for there are many species in which it does not exist—unless we are to consider that the single floral envelope that occurs in these cases is a calyx and not a corolla; or that, when it has partly the usual character of the one, and partly that of the other, it is to be considered as a compound of the two "soldered" together.

The next part of the flower, in those that are called perfect flowers, that is, which consist of as many different kinds of parts as flowers ever consist of, is the *corolla*. That is seldom green, and when it is separate from the calyx, it is always above that, or farther from the peduncle. The divisions of the calyx, when they extend down to the receptacle, are called *sepals*, and those of the corolla are called *petals;* and when the one or the other is in one piece, the calyx is said to be *monosepalous*, or the corolla, *monopetalous*. The petals of the corolla and the sepals of the calyx are generally equal in number; and they alternate with each other; but many flowers have those parts irregular. There are sometimes little membranes, or abortive leaves at the bottom of the flowers, to which the name of *bracteæ* is given, in the same manner that the name of *stipulæ* is given to similar appendages at the insertions of leaves; but neither of these perform any important function in vegetation, or are of much use in discriminating plants. When the calyx and corolla are both wanting, the plants are said to be *achlamydous (achlamydeæ)*, that is, having no garment or mantle to the essential part of the flower; when there is only one, whether that one is to be considered as calyx or corolla, then they are called *monochlamydous*, having one mantle; and when there are both calyx and corolla, the flowers are said to be *dichlamydous*, or to have two mantles.

The third part of a flower to which a general name is given, is the *nectary*, which is not essential to fertility, any more than the calyx and corolla. The nectary is sometimes wanting altogether; at other times it is a mere depression in the calyx or the corolla, or the several petals of the latter; and at other times again, it is a separate organ; but, whatever may be its form or situation, the chief office which it performs is that of containing, and in all probability secreting, honey.

The remaining, and only absolutely essential part of the flower, are the fertilizing and fertilizable organs. The former are called *stamens (stamina)*, and the latter *pistils (pistilli)*: and each of them consists of several parts. As the pistil is the organ that remains longest on the plant, and the one which at the first contains the rudiments of the seeds, and in which the seeds are at last brought to maturity, it may best be made the first object of notice. The whole organization of the pistil is called *gynia* (γυνή) —that which produces or brings forth, because it is immediately from that that the seeds are obtained. The top of it is called *stigma* (the mark), because on that there is a little depression, as if the surrounding edge were turned over in whole or in segments. The part that bears the stigma on its apex or point is called the *style (stylus)*, that is, the pillar, from its form; and the remaining part is called the *ovary (ovarium)*, because it contains the seeds, or eggs *(ova)* of the plant. The ovary is situated at the base of the style, so that the stigma is at the one extremity of that organ and the ovary at the other. The ovary consists of one or more cells; and sometimes the style is cleft into as many parts as there are cells, and sometimes not. The body of the ovarium is sometimes called the *carpella* or *pericarp*, because it surrounds the seeds; and if it consist of several parts or scales, these are called pericarpal leaves. The ovary is the really important part of the fertilizable organ, because it contains the seeds, the only part of the whole organization that is to be fertilized; and, in some plants, the other parts are obscure, or probably altogether wanting.

The stamens consist of two parts, the *filament*, or thread, and the *anther*, which is a little sac or vesicle seated on the top of the filament, and generally coloured yellow, brown, or black. The name *andria* (ανήρ), the fertilizer, is sometimes given to the whole organization; though the real fertilizing part be the *pollen* (dust), small vesicles of very light and inflammable matter, which is contained in the anthers.

The pistils and stamens, or those parts that answer the same purpose, are sometimes both in the same flower; sometimes they are in different flowers on the same tree; and sometimes they are on different trees; but, in what situation soever they may be found, the application of the pollen of the one to the stigma, or at least to the ovary of the other, is always necessary for perfecting the seeds of every flowering plant. On that account this union of the two parts of the flower is called *gamia* or *gamos* (γάμος)—the marriage; and hence the distinctions of *pheno-gamous*, or plants with *seen* flowers, and *crypto-gamous*, or those on which flowers are not seen.

This application of the word gamos is, of course, purely figurative; and the figure is far from a good one, inasmuch as a solemn *covenant* between two human beings has really no resemblance whatever to the *fact* of one part of a flower fertilizing another part. It is true, in as far as observation goes, that *union* is the universal law of Nature in the renewal or reproduction of her living works. There is therefore an *organization*—an ACT of organizing, previous to the most rudimental existence of every living thing, be it animal or be it vegetable; and could we bring the certainty of that, in every case, within the limits of our knowledge, the boundary between the living world and the dead would be defined in the most perfect manner; and we should not have dreaming men tumbling themselves from the firm ground of philosophy into the dark abyss—where, though there may be much "device," there is no "knowledge;" and floundering there, in quest of a "*living principle*," in "*amorphous*" or inorganic "matter."

Now, in all cases that we can examine or understand, the living principle does not exist in any one kind of matter, and is not in these cases material, or a quality of matter at all, but results from the fact of the action of one kind of matter upon another. What is the natural inference? Is it that nature departs from her general law there? or that we are merely unable to find out the act of accordance with that law? That question is very much the same as this one: "Are we to admit our ignorance in cases where, hitherto, it has been impossible for us to have knowledge, or are we to throw the blame upon our Maker?"

All that we can reason about the mode in which the seeds or other embryos—whatever name we may give to them, of the plants of which we are unable to see the flowers, are produced, must be from analogy; and that analogy must be taken from the living world. Nor, if we feel that there is that relation which is the essence of a just and true analogy, can there be any harm in thus reasoning from analogy; because there is in fact *no other* mode of reasoning.

The belief of the uniformity of the laws, that is, the successions of the phenomena, of nature, is innate, or co-existent with the very first instance of reasoning; and it is *the foundation* of that and of all future instances; so that where observation fails, and we must have recourse to analogy—and we never can find by the senses any tie or *vinculum* between the two facts the one of which the most invariably follows the other, simply because no such tie can have an existence, otherwise it would be a third fact, the consequent of the first, and the antecedent of the second of the other two—the uniformity of the law, or the succession in nature, is our only guide. And it is the very same with the *unhappened* as with the *unknown*. Why, for instance, do I write this digression? For no other reason than that I believe it will be read; and thereby, by making me useful to other people, make them useful to me; and it is the same in every human thought about the future, whether or not the thought be so vivid as to become what we, without knowing very well what we mean, call *will*, and be followed by action.

The general law of nature, in so far as we have discovered it, and *to us* that is *the whole law*, is that the *genesis* of every individual living being is *an act of organizing*, and that the instant *embryo* is a united thing—or something that may be dissolved or die; and, as the primary union has in it nothing analogous to that which takes place in matter which is not organized, so neither can the death be *similar* to any operation of analysis mechanical or chemical. That the consequences are not always the same, is no argument; for whenever the parts of the organic being come within the limits of cognizance, they also come within those of the laws of matter.

In animal life we find varieties: the functions are in different individuals, in the same individual, or in nearly the same portion of the organization of the same individual, just as in vegetables they are in different plants, in different flowers on the same plant, or in the same flower. As the seeds of some plants vegetate only in the earth, so do the eggs of some animals; and as many plants may be separated by division into many apparently entire plants, so may some animals. These facts do not prove that a plant and an animal are the same, any more than the fact that they may both be grafted, proves a rose and a nectarine to be the same; but they prove the uniformity of the law of nature; and therefore, as mere locality or distance has nothing to do with the act, except to prevent it, when the distance amounts to a certain quantity, we are not warranted to infer that, in those plants which have no flowers, or in those in which the germs can be produced in any part, or even in those of which the germs are too minute for our eyes or our microscopes, there is a departure from the law of nature, and that analogous productions, which are not in any other case produced without an act of organization, spring in these cases out of dead matter, without any act at all. That would be not only elevating death above life, but it would be endowing it with *creative* power,—fancying not only "a provisional creation waiting to be organized," but finding "an unprovided creation waiting to create—itself." Of course, if we use the word *gamos* for the act of organization in plants, the word *crypt* (κρυπτος)—that which is hidden, is a very simple and proper distinctive epithet. But we must be careful not to deny the existence of that which is merely hidden; and violate nature, because we do not know that which our organization is not fine enough for observing. As well might we become sceptic of the perfume of a rose because we do not hear it, or of the sound of our own voice because we do not see it.

The position of the stamens, with reference to the ovary, is made a distinction in plants; but as the whole of the flower has its supplying vessels from the peduncle, it is only one of external appearance—a distinction which is one of adherence and not of origin. When the stamens adhere more to the ovarium, or seed-vessel, they are said to be *hypogynous;* and when they adhere more to the calyx, they are said to be *perigynous:* as to their connexion, it may be traced from them all down to the stem of the plant, until they have performed their functions and fall off; so that the organization of the one energy cannot be said originally to differ from that of the other, either in elevation or depression. The whole floral parts are sometimes above the ovarium and sometimes not. Thus the calyx is found on the extremity of a haw or a hip, but at the base of a strawberry or a filbert; and as that is much more uniform among plants that have other appearances in common than the adhesion, it is much more useful as a character. From what has been said respecting that process of which flowers, in cases where they are visible, are the organs, it will readily be seen that there can be no general character of a flower; and that, therefore, the minute descriptions must be those of particular flowers; and they will be more appropriately noticed in noticing Orders, which have a particular form in common.

Seeds.

While the perfected seed remains in that state, it may be considered as a repose of the principle of vegetable life, a repose longer and more complete than that of the bud in its hybernaculum, and one which, if the seed is not placed in those circumstances which will be afterwards favourable to germination, would never be disturbed by any internal action of the seed. As, therefore, there is no vegetable action in the seed, all that requires to be stated respecting it in this place is the mere description of its parts.

In passing, however, it is worthy of remark, that as the seed is a more lasting repose than that of the bud, so the seed produces a more lasting vegetable than that which is obtained from a part of the plant; and that, though a particular variety may be preserved more unaltered for a certain time by the latter method, yet there must, sooner or later, be a return to the seed for permanent vegetation. This is not to be believed to the full extent, so happily ridiculed by Butler in the case of the "Taliocotian noses," which perished sympathetically at the death of the subjects from which they were taken. We are not to suppose that all the grafted and budded plants die at the same time with the stock from which they are taken; but as the grafted or budded plant is not one symmetrical individual, having the vessels of the two parts formed exactly alike—for if that were the case, the operation would be of no use—the wood that it makes cannot be so perfect, and, therefore, so permanent as that of an entire plant from the seed; and if successive graftings take place, it is natural to suppose that each time the wood will be more deteriorated, and the plant consequently of shorter duration, under the same circumstances of soil, climate, and culture. What the amount of the deterioration each time is, and how many times might be necessary to shorten the duration of the plant to one year, or to any given limited number of years, is not stated, and, from the many variations that may accrue from treatment, it would be very difficult to ascertain. But, as will be attempted to be explained in the next chapter, grafting and every other plan by which an increase of fruit, or of the farinaceous, pulpy, or vinous properties of fruit, is sought, in opposition to the greater acerbity of timber, tends to diminish the general vegetation of the plant; and every one may observe that the forest outlives the orchard, that the meadow outlives the artificial grasses, and that the corn plants are all annuals. Whether they were so in a state of nature we are unable to say, for we know them not in that state; but the facts are conclusive as far as they go; and they prove that, though there are other means of propagating plants, applicable in some cases, the general mode is that by seeds.

When the act of organization has taken place, all those parts of the flower, of which the office is accomplished, decay and fall off; and they do that much sooner where the purpose of nature has been accomplished than where it has not. The ovary alone remains to mature the seeds. As the ovary perishes, too, when the seeds are matured and fit for germination, even that is no part of the young plant, and communicates nothing but to the seed.

The parts of a perfect seed are the *coats* or *tunics* and the *nucleus*. The coats are usually three, and when that number cannot be found on dissecting the seed, it is probable that those which appear to be wanting adhere to the others, or to the contained parts, and are so fine that we are unable to separate them. The outer coat is seldom wanting, and it is found before the act of germination takes place. It is without any aperture, for when it ripens and separates from the ovary, the termination of the vessels by which the growing seed was nourished completely closes; though in cases where the outer coat is thick and the vessels have been short, as in the seeds of beans and other legumes, a scar is left, which is sometimes called the *hilum*, or the *nothing*, being a mark and no more. In general the outer coat is nothing more than a mere protection, as it is only in some of the monocotyledonous seeds that there is any connexion between it and the parts within. It generally contains both vessels and cells, and sometimes a thin pellicle or epidermis can be separated from it. There are some additions to the outer coat, but they are not essential. These are hairs, hooks, down, feathers, and other means of protection or conveyance; and in some seeds there is a loose membrane called the *arillus*, which wholly or partially invests the outer coat. The second or middle coat invests the whole seed, like the former, and, like that, has no aperture; but it is never found before the seed be fertilized; and it is often not observable, being, probably, in these cases united with the outer one. There is some analogy between these two coats of the seed and the external parts of the flower; the first coat having reference to the calyx, and being, like that, less altered from the common vegetable structure; the second bearing the same analogy to the corolla, and being a part, though not an essential part, of the seed, just as that is of the flower. In those cases where the second coat cannot be traced, there is a resemblance to those flowers that have but one envelope, in which the calyx and corolla are said to be soldered together; and when no tunic is found inclosing the whole seed, then the seed resembles those flowers that are without calyx or corolla. Where the middle coat does exist, the vessels by which the seed is brought to maturity are ramified over its surface.

The third, or inner coat, invests the nucleus in all its parts and their separate surfaces, and not as one sac, like the others. It is properly a part of the seed, and fine membranes, or sometimes fibres or vessels extend from its inner surface into the substance of the seed. It grows with the growth of the seed, and is analogous to the epidermis of the future plant, which is probably an expansion of this tunic or coat.

The nucleus of the seed consists of two sets of parts; the one nourished, and the other nourishing. The nourished part is the *germen*, which is sometimes well developed when the seed is ripe, and in other cases so small as hardly to be visible; but the latter circumstance does not warrant us to conclude that there is absolutely no germen in those seeds where we cannot see its locality, any more than the absence of flowers leads us to conclude that in those plants in which they are not seen there is no act of organization. This germen, when it is so minute, or so formed that we can see no distinction of parts in it, is called the *corculum*, or little heart; and the same name is sometimes applied to the centre of vegetation in all sorts of buds.

When the germen, or embryo, is what is called perfect, it consists of three parts: the *radicle*, which forms the root; the *plume*, which is developed into the leaves; and the stalk, by which they are united. The stalk and plume are, in fact, parts of the same organization, and the plume is merely the earliest bud. The embryo is united to the nourishing part of the seed at the junction of the stem and radicle; and that point is accordingly called the neck *(collum)* of the plant. There are never two embryos in the same seed, except in cases that may be regarded as deviations from the ordinary course of nature; but the functions of the parts of the embryo have a wider range. In those plants that *tiller*, or *stool*, that is, produce a number of plants from one seed in the same season, there is a power of at once throwing out two or three radicles; or buds are even produced at the neck, which throw out both radicles and plumes. In some plants the radicle is wanting, and the roots are thrown out by the lower part of the plume. In many plants both parts, reckoning from the neck, can throw out either stems or roots, but in others the distribution is from the original root and plume; and those plants in which the root will not sprout below the neck, as the stem or a branch from roots above it, rarely, if ever, form roots in the bark. The habits of the early embryo and the mature plants have not, however, been compared with that minuteness or to that extent which the subject probably demands.

The nourishing parts of the nuclei of seeds are chiefly the *cotyledons*, or lobes; though where there is only one, the name is not very applicable; and in many of these cases it is doubtful whether, even admitting the existence of a cotyledon, that be the part in which the nourishment of the young plant is contained. The office of the cotyledon is not so much to contain nourishment as to apply that nourishment to the plant—not so much merely to furnish the materials of vegetation as to take an active part in the process,—to do for the embryo plant what the leaves do for the advanced one; and, therefore, excepting the embryo itself, the cotyledons are the most important parts of the seed.

When there is but one cotyledon, or when there are more than one to which the name might perhaps be given, but these are all on one side of the axis of vegetation, the plant is said to be *monocotyledonous*; and when there are two, opposite to each other, or a number, whatever that number may be, surrounding the axis of vegetation, the plant is said to be *dicotyledonous;* and those peculiarities of the seed are accompanied by the differences in the whole economy and habits of the plants to which allusion has been already made.

The cotyledons contain vessels, but they are chiefly made up of very fine cellular substance, in which, in dicotyledonous seeds, the chief part of the nutriment, or albumen, is contained; but in many of the monocotyledons, such as the grasses, only a small part is contained in the cotyledon, and the remainder and greater part in a separate tunic, which communicates with the embryo through the cotyledon. Whether it is contained in the cotyledons, or in a separate tunic, this albuminous or nutritive matter varies very much in different plants, and neither the quantity of that nor the magnitude of the seed has any necessary reference to the size which the plant is to attain, or the period for which it is to remain in the living state. One thing, however, may be remarked as worthy of investigation: in those seeds in which the embryo is the most developed previous to the common process of germination, the albuminous matter is most in the cotyledons; but the future effects of that upon the plant have not been studied with sufficient care. It is certain, however, that the seeds which have their embryos thus forward, germinate and sprout much more easily than those which are in a more minute and elementary state.

On subjects of this kind it is always dangerous to theorize; but in this case the analogy is so inviting, that one or two conjectures may be hazarded, not as established facts, but as guides to the discovery of them, the only way in which theory has ever been useful—and theory in this way (right or wrong at the starting) has been the legitimate, and, perhaps, the chief guide to actual discovery. The more that the embryo has advanced, the more are all the structures in the nucleus of the seed distinguishable from each other, and the more, of course, does the whole seed approximate to the nature of a plant in actual vegetation. But it is in their vegetating state only, and not in their dormant state, that plants are subject to the action of external agents,—that they are capable of acting vigorously under one kind of circumstances, or of having their vitality wholly destroyed under another. Now it is known that the plants which spring up without apparent sowing, and even without apparent seeds, the existence of which is now, for the want of a better term, said to be spontaneous, and was once said to be equivocal—or produced without any proper beginning after the manner of other plants—are precisely those in which there is the least development of the seeds, not those species in which any globular or otherwise-shaped body to which that name can be given is found. The cotyledonous seed, in which the corculum of the future embryo is a mere point, and in which the cotyledon of that embryo is a mere tubercle adjoining that point, is not so easily called into action, and not so easily destroyed, as the seed in which all the parts are well developed and defined. Carry the matter a little farther, to the seed in which there is no traceable corculum or cotyledon, but in which the whole seems one inorganic mass, and you are nearer to that state of the organic body in which dimensions cannot be seen in it or predicated of it: and what is the inference? Why clearly that it will be still less subject to casualties than the most imperfectly developed of the cotyledonous seeds; that it may remain for years, for ages in the earth, in the waters, floating in the air, nay, perhaps, may pass uninjured through the fire itself—may certainly be taken into the systems of annuals and other plants, and may escape again without having its vitality in the least impaired. Hence, whenever the combination of circumstances favourable to the development of its latent energies is brought about, whether it be by an escape into the common air, or by the production of a putrid or decaying substance the result of general or topical disease, the little thing may begin to work, and may, by agencies which are contained in that which is too small for any microscope to measure, regulating and modifying agencies from without, elaborate the structure and display all the perfection of its species.

Though it is a truism, it is by no means an unimportant one, that where there is the most combination and composition of organs there must be the greatest chance that the whole organization shall be destroyed. We have already seen that organization is not only the final structure but the primary cause (if we may so speak) of every thing that lives. That primal organization is the union of only two parts. In what quantity we cannot tell; but certainly in very small quantity, and probably that of ultimate particle with ultimate particle, as is obviously the case in the formation of a perfect binary compound in chemistry, and, therefore, in magnitude as far below the smallest object of the microscope as that object is below the globes that compose a planetary system. If that be the case, and it is difficult to believe and impossible to prove that it is not, then the more nearly that we can approach to that primal state, the object of our search is the more safe from destruction. And, as was said in the former subdivision of this section, we have the law of the general analogy of life on our side. The young of the warm-blooded animal cannot be, till it is a perfect animal itself, separated from its parent; the egg of the bird may with proper care be kept for weeks; that of the fish can be for months in the sea; and that of the insect can remain for a very long time, and admit of being frozen or boiled. In all these] cases the farther that the embryo deviates from the perfect animal—the nearer that it, as it were, verges upon nothing—the more strong is it, the more fortified against destruction; and if that be a general law in the animal world—and it is one which does not necessarily involve one of those characters which distinguish the animal from the vegetable—how can we resist the tracing of a similar law among vegetables—more especially as we find that those plants, the germs of which would, by such a law, be the most indestructible—are those that we meet with at the times and in the places, and under the seasons and other circumstances, which are the least favourable to the growth of those seeds in which the embryo plants are more developed?

And when we pursue those speculations in the spirit of genuine philosophy, and the mind becomes warmed by their beauty and expanded by their sublimity, we catch glimpses of something higher than the mere science of matter. When we come nigh to that shadowy bourn at which expanded nature appears to touch the regions of unexpanded essence, we feel conscious of an ubiquity of existence—just as we feel conscious of an eternity of existence when we approach the bourn of day-divided time. The glimpse that we get is dim and fleeting; but to those who do get it, it casts, for the moment, all the cares and troubles of the world into utter oblivion, and gives us an assurance and a foretaste of that glorious state, in which sighing and sorrow shall have no place.

CHAPTER V.

PHYSIOLOGY OF PLANTS.

In a philosophical point of view, this is by far the most interesting department of the science of plants; but is the one which involves the greatest difficulties, and therefore the one in which there is the greatest danger of error. That a point or particle of matter, of the individual existence of which there was a few months previously no sign, which when it did appear was all but too minute for the microscope, and yet which in the course of years should ascend many feet into the atmosphere, and spread its organization over many yards, while its progeny suffice to ornament a county—should do all that by means of a power which we must suppose to have existed in the invisible point,—that the faculty of growth (as we may call it) should thus, by its own energy, expand till the result be visible in millions of organizations—is so much superior in kind to any thing that man can accomplish, that one can hardly blame the Hindoo, who fancies that he finds godhead in grass, or those other ignorant nations who fall down and worship the trees of the forest. And they are but one step from the true object of their worship, which is far nearer than is sometimes attained by those who claim for themselves the possession of a more lofty and enlightened philosophy.

The error of those philosophers, whether they be so in reality or only in name, is, in truth, a more absurd idolatry than that which has been mentioned. The savage sees God in the operations of nature, and he simply adores: the pseudo-philosopher sees himself in them, and goes about to frame hypotheses in which he attempts to mould their phenomena to his own similitude. These errors are found whenever men of unphilosophic minds, whatever may be the extent of their *simple* knowledge, or the authority under the sanction of which their dreams are sent forth into the world as realities, treat of philosophical questions. The notice of that error is in itself a proper introduction to the subject of this chapter; and that it is far from being unnecessary will appear from the bare statement of two positions in the physiology of animals that have gone forth to the world in the most imposing and accessible form, and by the authority of more than fifty names, which the public cannot be blamed though they consider as a guarantee for approximate, if not absolute, truth.

In the one case the facts are these:—long ago there were many partridges and many people in a certain district of Asia Minor; that the partridges were in request by the epicures of the olden time; that the people have been few for centuries; that the partridges still abound, and that they are shy: the inference is in these singular words; "Might not this shyness have been transmitted to them as an hereditary habit from the times when the country was populous, and they were pursued by the inhabitants"!! Shades of Plato and of Aristotle!—where be the traces of your mighty minds among the modern inhabitants of your country? Shade of Shakspeare!—where is thy testamentary habit among the dramatists of this our time? Young, Woolaston, your graves are not yet green!—where be your mantles? And if it can be so among men, where one generation schools another, and where the knowledge of all generations *may* go upon record, how much more must it be among birds? The very sportsmen refute the philosopher. The birds are shy one year, and not shy another; but the veriest clod that draws a trigger never fancies that there is any thing hereditary in the matter.

The fact, in the second instance, is the dangers to which insects are exposed in the egg or larva state, and the inference runs thus:—They "are endowed with an almost miraculous foresight, and with an ingenuity, perseverance, and unconquerable industry, which are not to be paralleled even by the most singular efforts of human contrivance"!! Foresight, as predicated of created beings, means, *having seen before;* and the only experience that an insect could have of danger in the egg or the larva state, would be having itself been eaten, or otherwise destroyed, while in that state, which would at once end its knowledge, its cares, and its labours.

It is not meant to be said that each and all of the fifty judges, under whose sanction and recommendation these sentences appeared, understood them in a perfectly literal sense. They are unquestionably figurative expressions, arising from the poetical ardour of those by whom they were originally penned; and the gallant judges spared their error for the sake of their beauty—just as other judges are wont to do. The love of personification is very natural in minds of brilliant endowments, and would be delightful to every body, if every body could discount it down to its real value; but every body is not capable of doing that, and therefore among ordinary minds the most beautiful of those figures becomes, as the wise man most emphatically says, like "a jewel of gold in a swine's snout." In an oratorical age there is always danger from tropes. Like hackney-horses, the orator can yoke them to any vehicle; when yoked they dash on, and so stir the atoms, that instead of perceiving clearly what is drawn, and for what purpose, plain minds see nothing but a cloud of dust, which, for aught that they know, may be raised by an idle whirlwind.

But if there be error produced by confounding the instincts of animals with human reason, there is equal danger of error in confounding the habits of plants with these instincts; and though the language of each department of nature, as perceived directly in that, be as plain as it is forcible; yet as, when it comes to be translated into human speech for the purposes of communication, there is but one tongue for all, and that tongue the human one, the figurative application in the other cases must be constantly and carefully borne in mind. When we speak of the life, the sleep, or the motion of plants, we must always bear in mind that these have no analogy whatever to the functions to which we give the same names when we speak of animals, any more than the instincts of animals have any analogy to the phenomena of mind. If we confound them in their faculties we can hardly avoid confounding them in their fate also; and thus, while we endow them with the attributes of mind, we must either grant immortality to all, or deny it to ourselves. Nor is there any doubt that much of the scepticism that exists arises from this error; and thus that which in itself is the most wholesome food of the mind, becomes its most baneful poison—upon the general hypothesis that the abuse of the very best things, being the converse or the opposite of them, becomes tantamount to the very worst.

In giving a short outline of the functions of plants, that is, the changes in appearance and form which they undergo, with the external agents that appear to be concerned in those changes, the clearest as well as the shortest method will be to divide the subject into the following sections:—1. Vegetable life; 2. Germination of seeds; 3. Vegetation, or growth in plants; 4. Functions of particular organs; and, 5. Peculiar phenomena and decay. Each of these would admit of much subdivision, and among professed physiologists they are the subjects of many volumes and of not a little dispute; but as we profess not to write for these, a slight sketch of the great points must suffice. Nor shall we offer any pictorial illustrations of the points. The finest coloured drawings fall far short of what any one may see in nature in briefer time than that in which these could be examined; to nature, therefore, the student who wants information and pleasure should go, and the picture would but keep him a little longer in ignorance. Within our limits—within any limits, we cannot hope to make "the picture at one for the page;" and as we have no greater hope of making the page atone for the picture, we omit the picture and leave the page to its fate.

SECTION I.—LIFE OF PLANTS.

Of all the developments in creation life is that to which we cling with the fondest attachment in ourselves, and admire the most in all else in which we can watch its phenomena, or speculate about its functions. Of its essence we know nothing, because our direct perception of external things is limited to physical subjects; but we find certain phenomena in animals and in plants which we are utterly unable to explain by the laws of physics, whether mechanical or chemical; and hence we say that they are owing to vital causes; that the organization by which they are displayed is living, or has life. Where no such phenomena are observed, we say that the substance without them is dead; and when they have once been and then cease, we say that it dies. In coming to the decisions, in virtue of which we apply these distinctive and opposite names, we must, however, proceed with the utmost caution. Before we abandon our physical inquiry and resort to the hypothesis of life, we must be certain that we have exhausted that inquiry; and before we pronounce the sentence of death we must be sure that the vital energy is gone, and not merely suspended; for we have evidence that life, in some of its forms, can remain inert, but not dead, for years, or for ages, and return again to its activity when circumstances favour it.

That wherever there is the development of life there must be organization—certain definite structures to perform certain definite functions—seems to be a law from which there is no anomaly. The primary volume in which the life is, may, in all cases, be too minute for the eye or the microscope; but that is no argument against there being an organization there. As far as the microscope can scan, the smallest animalcule that it brings to our view, is as well organized as an elephant or a whale; and who dares to say that living beings may not exist millions of times smaller in proportion to the animalcule than the animalcule is in proportion to the whale? If the question were one relating to the products of human art, the minuteness would speedily have a limit, because the smallest parts must be seen by the eye and manipulated by the touch; but the works in question are made alike without eyes and without hands, and therefore to their Maker all magnitudes are the same.

Another general law of life seems to be that it passes from one organization to another only by transmission. Be it vegetable or be it animal, when death passes upon it, that individual organization can, according to the law of nature, live no more; be it elephant or mite—be it the monarch of the forest or the first microscopic dot of mould upon the almost microscopic fibre of a moss—if the bones or other organic parts of it—to say nothing of the constituent elements of which those parts are made up—be once scattered in the dry valley, the creative "spirit must pass over them" before they can again exhibit even one of the phenomena of a living thing. We may take an organized being, a plant for instance, while it is yet alive; and we may analyze it into what we call its constituent elements, without any loss of substance which we can detect by the nicest balance; but we cannot reverse the process or make one step towards it—no, not so much as the organic structure, independently altogether of the life. According to the analysis of Guy Lussac and Thenard, 100 grains of oak-wood contain

Carbon	52.53 grains
Oxygen	41.78
Hydrogen	5.69
	100. grains of oak.

All these elements we can obtain in a pure state, or as the oxygen and hydrogen are almost in the same proportion as they exist in water, we can have charcoal and water; but mix and treat them as we may, not a single grain of oak-timber will reward our labours, nor any organic being whatever, unless the seed or other germ of that being has found its way into our apparatus. With the forms of inorganic matter it is not so. In very many cases we can take the crystal which nature makes, melt it into a liquid, sublimate it into air, pass that air through countless new combinations, and ultimately get back the crystal without loss. And as we can do this with more substances in proportion as chemistry is better understood, we have reason to believe that the same may be ultimately done with all inorganic substances; but in the case of organic ones the insuperable difficulty is at the very threshold, and we can have no hope.

In all speculative ages, that has been not a little mortifying to human pride; and, as has been the case in many other matters, where the natural light has ended, man has begun with an artificial one. The atoms, the void, the downward motion, the little *voluntary deviation* from the straight line, "*incerto tempore, incertisque locis*," as Lucretius says, have long been familiar; and it may be noticed that the whole difficulty of the matter—the reason why a plant is a plant, and an animal an animal—consists in this very deviation, of which the Epicurean admits that he can give no account; and thus the system built upon it is only fancy, and should not lead to error.

A small branch of this doctrine has been revived of late. Some of the observers on the Continent have—chiefly from observing a motion of fluid, or particles, in the pipes or tubes of knotweed *(chara)* —a small gelatinous plant found under water in springs and rivulets, and also in ditches and bogs,—concluded that there is a vitality in matter which is *to be* organized, antecedent to all organization. Following out this theory, an attempt has been made to settle the "uncertain" deviation rom the "downward motion" of mere gravitating matter, which Lucretius did not dare to know. The observation of Marivaux, that Fontenelle had "too much good sense for knowing more about the soul than other people," applies somewhat forcibly here. It seems that, if it may be so said not irreverently, this unorganized living matter is the clay waiting for the potter; and that (if we can rightly understand a matter so very recondite) the very same portion of this clay may, according to the potter—that is, to circumstances—become a lichen or a sea-weed, a vegetable or an animal. If that be the case—if it be possible to change a plant into the humblest animal, even into a water-hydra, which may certainly be propagated by cuttings like a plant—then the conversion of an oak into an elephant, or of a bundle of thistles into a donkey, is brought within the pale of possible expectation. The words of a most industrious Professor, when speaking of the "slime" which "consists of algæ in their simplest state of *organization*," are worthy of being quoted. "One might," says he, "call it a provisional creation waiting to be organized;" and he adds, "and then assuming different forms according to the nature of the corpuscles which penetrate it or develope among it." Here the very same substance is first "algæ, in their simplest state of organization;" then it is "a provisional creation waiting to be organized;" and, at last, it is to assume different forms, "according to the nature of the corpuscles which penetrate it or develope among it." Now, if it be young algæ, even in the simplest state of organization in which they can be visible or exist, it cannot, at the same time, be "waiting to be organized;" and if it be waiting for the corpuscles (what are they?) which penetrate it or develope among(st) it, it cannot be algæ but as to serve for the *locus*, or the *pabulum*, of those foreign corpuscles. If it is merely meant to be said that the *germs*, or *sporules*, or whatever they may be called, of the algæ, are jelly-like, we believe that the same may be said of the very earliest organization of all vegetables and their seeds, and thus we are where we began.

Let it not be thought that these observations, any more than the former ones respecting the memory of the Caramanian partridges, and the foresight and ingenuity of the insects, are made in the spirit of hostile criticism, or with the least intention to undervalue the ingenious persons by whom the words commented on were penned. Far be it from the writer of these pages to injure or envy any man's laurel—wear it as he may: but still, the failures of adepts are the best beacons to set up in the paths of catechumens, to point out to them those places which it will be vain for them to attempt to explore.

As the abstract principle of life is not, and by means of the organs of the human body cannot, be known, there can be no line drawn, as the boundary between animal and vegetable life, other than that which may be observable in the organization and the resulting habits; and except upon the very confines, where vitality itself is doubtful, the unlearned and learned are about equal judges.

SECTION II.—GERMINATION OF SEEDS.

The seeds of plants, considered as depositories of the unexcited vital principle in vegetables, may be noticed to more advantage in another section; hence it will be necessary here only to notice that change of the seed into a young plant, to which the name of germination is given. In the seeds of phenogamous plants, the only vegetable germs to which the name can with perfect propriety be given, there is always contained within the tunics of the seed an organized embryo, and a portion of inorganic matter for the first nourishment of that embryo. The inorganic matter is, however, not one mass, but contained in cells of organic tissue, which are in the cotyledons, or seed-lobes of those plants that have them, and in cells formed by the inner tunic or coat in those that have no cotyledons. The inorganic matter, though different from the albumen of the chemists, has been styled albumen by some of the more eminent writers on vegetable physiology.

The real ingredients which are most abundant in the albuminous part of seeds, whether that part be divided into cotyledons or not, are mucilage, starch, and sugar. The mucilage and starch together form farina or flour. The three substances do not differ much in their chemical composition. Starch and gum may be converted into sugar; and so indeed may linen rags, saw-dust, or any other vegetable substance (excepting perhaps some of the peculiar products) if they be boiled for a sufficient length of time in diluted sulphuric acid, or in water alone in the case of those that approximate the most nearly to sugar.

The primary step toward germination is the conversion of the farinaceous or albuminous part of the seed partially into sugar; and as that is an operation wholly chemical, the consideration of any specific vegetable action in the organic parts of the seed is not necessary for the effecting of it. In this primary, or rather preparatory action, the presence of light is not necessary; and indeed the absence of it answers better; for, other circumstances being the same, seeds germinate the better when they are buried in the earth; but they must not be so deep as that the air cannot have access to them. The mere beginning of the process is probably effected without the agency of air, but that agency is soon required.

The initiatory agents are moisture and heat, which must act together. When perfectly dry, the seed does not germinate, neither does it do so if the temperature is not above that of freezing; and if the air be excluded, and the seed kept in water as warm as 60°, its substance is gradually decomposed. The first effect of the moisture is to swell or augment the volume of the seed; and that is done with very considerable force. And this initial part of the process goes on in the seed although the embryo be removed, or the vitality otherwise destroyed, which is another proof that there is no specific vegetable action. It is probable that in this early part of the process the water is imbibed by the seed in an undecomposed state, and that the heat is necessary to open the minute pores of the coats; for seeds soften much more rapidly in warm water than in cold. The length of time that the mere expansion by the water requires, is in proportion to the dryness of the seed and the firmness of its coats. Under favourable circumstances, the seeds of legumes and grain plants begin to burst the outer coats about the second day, while the stones of many of the pulpy fruits require two years. Partial steeping, or maceration in pits in the case of the more obstinate seeds, of course accelerates the initiatory action.

The next step of the process is the conversion of the albuminous into saccharine matter; and when that begins, the embryo begins to act. Atmospheric air, or oxygen, is essential in this stage of the process; but no part of the oxygen enters into the seed. It abstracts carbon, and is converted into an equal volume of carbonic acid gas. This carbon most likely exists in the seed in a solid state, but the expansion of it is not so great as the condensation of the oxygen abstracted from the atmosphere,—the specific gravity of the acid gas being to that of the oxygen as about 15 to 11.

In consequence of that, we have, at the contact of the atmospheric air with the seed, a process similar to that by which it has been mentioned that vegetable substances are converted into sugar. There is moisture, and there is heat furnished by the condensation of the oxygen; and, though diffused the latter would not be great, the action at the surface of the seed must be very considerable. It is easy to see that the immediate action of the heat must be at the surface, because the atmosphere cannot be supposed to penetrate the substance of the seed at the same time that the seed is expanding with a force greater than the pressure of the atmosphere; and, independently of the direct experiments which have been made upon the subject by Dr. Hales and others, the force of expansion must be greater than the pressure of the atmosphere, otherwise the seed could not expand at all. Here again, therefore, we see that the conversion of the albuminous and almost insipid matter of the seed into a saccharine milky juice, fit for the nourishment of the embryo, is wholly a chemical matter, and might be produced by the heat, moisture, and air, although there were no embryo there. This fact is worthy of bearing in mind, because it shows that mere chemical action can no more change albumen into a living plant, than it could so change a stone or a metal.

The organic structure and action of the embryo are next to be considered. The first stimulus cannot be ascertained; because the sphere of its action is too minute even for the microscope; but as the first change takes place in the food of the young plant, the more rational hypothesis is that the food stimulates the organs into action.

The embryo, though at first, to external appearance, a mere tubercle, soon divides into two parts, which take opposite directions—the *radicle* downwards, to form the first-root, or top-root, and the *plume* upwards, to form the above-ground part of the plant. Sometimes there is a difference in the period at which these are produced, and sometimes there is a perceptible stem or elongation between the plume, properly so called, and the *collum* or neck, by which the two parts of the plant are separated; but in all cases those organs take opposite directions, and those directions obviously originate in the vessels by which the nourishment is conveyed from the cells of the albuminous part, just as opposite directions are given to the two parts of a leaf by the vessels that come through the petiole and the mid-rib.

Even the simple matter of the opposite tendencies of these two primary parts of the plant—though not half so puzzling as the fact that there should be a plant at all, has come within the range of that fondness for analogies which has been such a pest to physiology. The plume has been said to "love the light" of the atmosphere, and the radicle to prefer "the darkness" under the surface of the ground,—though we never heard that virtue and vice were predicated of these *voluntary* choices of the two parts. When gravitation became the *alkahest* of the day, and was vainly applied to the solution of that which it never by possibility could solve, the difference in the specific gravity in the particles of the plume and the radicle produced their different directions. But when the position of the seeds during germination was inverted, and even when, during germination, they were whirled round upon wheels, as if at once to confound their gravitation, and puzzle them in their election of earth and air, the two organs still held their directions just as opposite as in cases where they were not interfered with.

But it is only in the primary stem from the plume and the top-root from the radicle, that those opposite tendencies are constant. The secondary roots, and the branches of the stem, are lateral at various angles, according to the habit of the plant. When the roots produce buds, the stems of these shoot upward, and change their radical character; the branches of many trees weep, or droop down at the points; some send down roots from the branches, as the Indian fig and some of the mangroves; others send down fresh roots from the lower part of the stem, so that they appear to stand on legs, as is the case with some of the palms; and in those trees that can be propagated by cuttings, the first rootlets from the planted end go down, and those from the sides laterally, and in many cases it is a matter of perfect indifference which end of the cutting is put in the ground. These facts are worthy of being borne in mind, as the means of avoiding certain errors in the physiology of the growing plant, after it has ceased to be nourished by the seed.

While the plant is in its young state, the only agents that appear to be necessary for its perfect development are moisture, heat, and atmospheric air. Even after that, no other agent is necessary to the mere growth. A good many years ago there was a potatoe plant in the tower of the old cathedral of Dunkeld, which grew to the height of probably thirty or forty feet in order to get at the glimmering light of a partially closed window. It was of course white, or, as the technical phrase is, *etiolated;* but the volumes of matter in the stalk must have been ten times the bulk of the original potatoe; and there were little tubers on the roots. The absence of light tends, indeed, to prevent the waste of matter; because etiolated plants have not so many pores; and the hearts of cabbages, and blanched lettuce and celery are much more juicy and succulent than the parts of the same plants that are exposed to the light. Still, however, light is essential to the perfection of most vegetables; and that and the green colour appear together,—the very earliest leaves and the rising cotyledons, as may be seen in the lupin, become green by the action of light.

What specific effects the light produces have not been fully known; but it is probable that the deoxydising rays separate the oxygen from the cortical cells in the plant; and leave the alkaline bases to form the green colours; for it is well known that alkalis revive the green colours of vegetables, or turn the red ones to green; while the effect of acids is quite the reverse.

Another thing: theory and experiment both lead to the same conclusion, that, aided by the action of light, plants decompose water, and both the oxygen and the hydrogen enter their structure in the solid state. When plants exposed to light, imbibe small quantities of water, they give out a little heat, till the water reach and moisten the leaves, and the cooling evaporation begin. The passing of a very small quantity of water into the solid state of its elements, would have that effect. Besides, plants that are etiolated are hardly inflammable. Now, it has been already mentioned that plants in that state contain water, rather than the elements of water in a solid state, and of course they tend more to produce cold by the evaporation of that water, than heat by the enlargement of the carbon, when it unites with the oxygen of the air. When, however, the elements of water are solid in the plant, the heat and light produced by their union are great. It is not, however, the province of vegetable physiology to enter into the theory of combinations; and when the leaves on the plumale are expanded and green, the work of germination is over, and the plant soon becomes an independent vegetable, deriving its nourishment and its increase of volume through the medium of its own organization.

There are some very curious meteorological questions connected with the germination of seeds; and among the rest, there is reason to suppose that the spring is warmer in agricultural districts, where the seeds of the crops are germinating, than in places that are covered with perennial grasses. The evaporation, and consequent cold produced by that are, in equal hygrometrical states of the atmosphere, in proportion to the acting heat. At the same time the temperature of the day and the night are more assimilated in pasture districts, and hence shrubs and fruit-trees that stand on grassy surfaces, suffer less from the spring-frosts than those that stand upon naked ground. These subjects, however, demand the perfect knowledge of many elements, few of which have been investigated with any care, and all of which demand practical observation, and not argument from hypothesis, how plausible soever that hypothesis may be.

SECTION III.—VEGETATION OF PLANTS.

We have now to take a very cursory glance at the action of the independent plant; and because the year's action of the tree does not differ much from the action of the exogenous annual, and as the endogenous plant bears some analogy to the exogenous turned outside (of the wood) to the centre, it will save repetition, and give a more condensed, and on that account, perhaps, a more satisfactory glance, to confine our notice to the tree; and the modifications of action can be noticed afterwards, when necessary.

It must be borne in mind that the tree, even when it has reared its stem, stretched forth its branches, unfolded its leaves, and expanded its flowers, to the very utmost limit of vegetable grandeur and beauty, is still the same identical individual that lay dormant in the little embryo of the seed, till the stimulus of the heated, softened, and sweetened albumen called it into action. We must therefore conclude, that how much soever the magnitude, the form, and the texture of its parts may have changed, the general law of its action must be the same. If not, we should lose, not the species merely, but the individual; the vegetable kingdom would be confusion, and the study of it impossible. Nature is however true to her purpose; and however our notions or our perceptions of them may change, she never violates her laws. In trees that hybernate, and more especially in those that shed their leaves in the autumn, the action in the spring very much resembles that of the germination of their seeds. The parts of the tree, when destitute of leaves, have been already described as pith, wood, and bark. The pith is most abundant in the most rapidly growing parts, whether these be entire plants or shoots. It is a cellular tissue filled with juice the first year, and at that time it probably answers the same purpose to the young shoot that the cotyledons answer to the embryo of the seed. As wood accumulates, the use of the pith appears to cease, though it continues in the new parts; and, after a considerable accession of wood, and especially after the growths of several years harden into heart wood, the pith ceases to have any action whatever,—the action then being carried on in the alburnum, or, as it is termed, the "sap-wood" of the tree. The whole pith and the cellular tissue of the sap-wood are those that answer to the albuminous part of the seed; and the vessels that surround the pith in the first instance, and those that are in the sap-wood afterwards, answer the same purpose as the *mammary* vessels, which convey the altered moisture of the cotyledons, or other depositions of albumen, to the young plants. The roots which have wintered, or acquired the proper ligneous structure, are to be considered as approaching to the nature of underground trunks; the young rootlets, by means of the *sponglets*, or little absorbent textures, with which they are furnished, take in whatever the plant receives from the soil; but there is an absorbent power in the leaves, and also to a greater or less extent in the green bark; so that the exposed part of a tree may be said to be, to a greater or less extent, mouth all over.

In autumn, when the shoots cease to elongate, and the only perceptible addition to the tree is the buds, terminal or lateral, the new matter is consolidated in the cells of the alburnum and in the liber of the bark. These terms are not confined to the layers produced in the year, but extend to a greater or smaller number of layers in one or in both, according to the kind, situation, and condition of the tree; but the action in them is always less and less as they are further and further from the union of the wood and bark.

When there are no bruises on the tree, the vessels of the wood and the bark both terminate in the buds, or, if they unite, it is through the tissues of the minute leaflets folded up in these; and they must be either very few in number, very small in size, or both; still there is even then some little action in the tree, unless when the temperature is as low as freezing; and in England, keen frosts seldom last so long as to penetrate to all the roots of a deep-seated tree. In proof of that, it is found that the rootlets accumulate much more new matter than the buds during the winter and the early spring. Sometimes that proves an evil, by making the tree "run to roots," and cease to be so vigorous above ground; but on the average it may be concluded that it acts beneficially, as the roots of the tree are the chief absorbents of moisture, at that early time which gives the character to the vegetation of the year.

The formation of the new bark and wood may be considered as the grand annual purpose of the tree as an individual; for, as the buds have reference to the following year, and the flowers and fruit have reference to other plants, they had better be considered separately. The matter absorbed, and the matter in the cells of the alburnum, are the materials out of which the new matter is elaborated. The roots are the principal absorbents; and therefore the progress is best traced from the root. Simply, then, there is an action beginning in the root, at the very sponglets of the roots, and continued to the remotest parts of the twigs; and when the leaves are developed, there is an action from them downwards to the roots. The upward action takes place chiefly in the alburnum, and the downward action in the liber. As, in the early part of the season, by far the greater part of the absorption takes place at the roots, not only because the absorbent system above ground is not then developed, but because the earth abounds more in moisture than during the warmer seasons, when the evaporation is much greater, and when the leaves absorb, and even again in part give back to the air a very considerable portion of humidity. At that time, therefore, the principal motion of the sap is upwards; it is found only in the wood, chiefly in the alburnum, and never in that central part of an old tree which, even in the season of greatest vegetation, is altogether dry.

But though, in the early part of the season, the sap be found only in the wood, and though its general motion there be upward, there does not appear to be any thing in the organization of the vessels which makes them *propel it* that way, in any manner analogous to that in which the central or muscular coat in the arteries of animals assists in propelling the blood to their extremities. The vessels of plants, even those that have the spiral or the annular form, have no action resembling that of muscles; when they are divided, the sap flows from either extremity with the same ease, and they absorb equally at either end. It is true that, if the roots of a plant be immersed in a coloured fluid, that fluid will ascend to the top; but it is equally true that if a portion with leaves on it has the cut upward, immersed in a similar fluid, that fluid will go the other way just as readily; so that there is really nothing in the vessel of a plant but a mere canal for conveyance; and the chief use of the spiral and circular structure of the vessels in which those structures are found, seems to be the resistance of compression, which, as every body knows, is much better effected by a series of hoops or spirals fixed upon each other, than by a parcel of straight rods set lengthwise into a tube. The sap remains in the cells and vessels of the alburnum until the leaves are expanded; and it does so simply because it has no where else to go, unless it burst its way through the bark, as it sometimes does, or make its way back again to the roots, and so escape into the earth. The descent for the purpose of escape is not very probable; but the lengthening of the rootlets, before there are any leaves, shows that some of the sap is not then rising. The evolutions of the rootlets that are made before the expansion of the leaves show something more; they show that in their substance the work of vegetation is not perfect; they have not profited by the light, but are white and uninflammable like etiolated plants. Perhaps it will simplify the remainder of this section if we divide it into subsections; and first,

The Sap in the Wood.

Respecting it there are two principal questions: What is it? What brings it there?

In answer to the first question, it may be said that by far the greater portion of the sap is water,—water in quantity sufficient for holding all the other substances in solution, and requiring to be very largely evaporated before the sap can attain the consistency of the very softest vegetable organization. As part of the sap is derived from the soil by absorption, and part of it from the solution of matter in the cells of the alburnum, there are three sources whence differences in the sap may arise. First, there may be differences of soil, and the roots of the plant can absorb from the soil only what is there; secondly, there may be differences in the part furnished by the cells of the alburnum, because that is a product of the peculiar organization and the action of the plant, and cannot be exactly the same in two plants of different kinds, and probably not the same in the same plant in different years, especially if the weather be different; and, thirdly, there may be a difference in the proportions of the sap supplied from the two sources. These differences must have very considerable effect upon all the products of the plant, whether wood, pulp, or seed; but the subject has not been investigated very fully—or very philosophically so far as it has gone. Those who have the science in these matters have not always the opportunity of observing; and those that have that, too often have not the science. In general it may be stated, that where the supply from the alburnum is rather in excess, the flowers are more brilliant, the fruit more racy and the wood harder; and that the circumstances are reversed when the excess is absorbed by the roots. The limit to which too much excess from the alburnum tends is stuntedness and gradual inaction, with an excess of fructification as long as the plant has power; and the extreme toward which an excess from the roots tends is volume, sponginess, and deficiency of fructification, with incapacity to stand severe weather. The regulation of these two supplies is the object of the cultivator; but the practice, though successful, may be said to be more empirical than scientific. The subject is indeed a nice one: the changes that one ounce of the absorbed fluid undergoes, as it climbs, inch by inch, to the top of a tree one hundred feet high, are so gradual that their progress cannot be known but by the result; and where there is no analysis there can be no philosophy. The mere chemical analysis of *sap*, without specifying all the circumstances of time, place, present weather, and last season, amid so many causes, proves not much. The following is Vauquelin's report of the sap of the elm:—

Water and volatile matter	1027.904 parts
Acetate of potass	9.240
Carbonate of lime	0.796
Vegetable matter	1.060
	1039.

From this it appears that, in that particular case, the water was to all the other ingredients about as 90 to 1. Water, therefore, though not the sole pabulum, is the grand vehicle in the nourishment of plants. The quantity of water, and also the kind and quantity of other ingredients, must depend in a very considerable degree upon the peculiar nature of the plant, as some require peculiar earths, some peculiar salts, some metallic oxides, and others nitrogen, though those in which that ingredient is largely found probably derive it from the atmosphere; as we shall see afterwards that certain organs of plants which can be matured only in the air, contain nitrogen, although the plants to which they belong contain little or none. It seems however that the changes in the properties of plants are far greater than those of the chemical ingredients of which they are composed; and therefore the chemical analysis, whether of plants or of soils, is not much to be depended on unless accompanied by a long and close observation of nature.

Let us next inquire "What brings the sap into the alburnum?" The answer is, the very same agencies that change the albumen of the seed *into* food for the embryo plant; only the sap has to undergo another change before it be fit for the ultimate vegetation. Whenever the matter which is in the cells and the vessels is raised to the proper temperature, it has the same tendency to absorb moisture as the substance of the seed; and it does so in the same mechanical way, for dead wood absorbs moisture as well as wood in living trees; and one cause of the rapid decay of the alburnum, or "white wood," is the absorption of moisture, and the decomposition of the matter in the cells and vessels by its means. This action in general commences in the roots, or the lower part of the stem, because the temperature there is warmest. As the temperature increases, so does the power of absorption; the moisture ascends, and the contents of the cells and vessels softens and in so far mixes with it. It is this mixture acted on by the air that gives a saccharine, an acid, or a bitter taste to the sap, according to circumstances. While the weather is variable, and before the whole tree be in action, the fluctuations of the sap bear some resemblance to those of a thermometer. During the day there is an ascent, which attains its maximum at the time when the heat is greatest; and during the night there is a contrary motion, though not to the same extent. These oscillations are so sensible, that a cloud on a sunny day will cause a downward motion; and a blink of sunshine on a cloudy day will cause a motion upwards, both of which will be reversed by a reversal of the weather. To what extent the *whole* liquid column oscillates cannot easily be known, but it is probable that the greater part of that which is taken in by the roots does so. These motions are so perfectly in accordance with the temperature, that, while the external resistance of the bark remains the same, it would not be very philosophical to ascribe them to any other cause.

When, however, the action reaches the branches the circumstances are changed, and the changes become greater as the twigs lessen, till it is greatest of all in the buds. The cause of the change is this: in the trunk of a tree, more especially an old one, great part of the centre is inactive; and so is the bark hard and unyielding; but, as the branches diminish in size, they, being formed of the last-grown wood, are more and more filled of vessels which are active, and when the buds are arrived at there is no ligneous matter. The expanding matter in the tree, upon the very same principle that a gun is discharged, or a bottle of fermenting liquor often uncorks itself, pushes in the direction of the least resistance, and thus the mechanical construction of the tree tends to diffuse the vegetative action over it. But, as the whole of that action depends upon the quantity of matter that finds entrance, it must, in every tree, after a certain accumulation of inert wood in the centre, begin to lessen, and other things being equal the diminution will take place most rapidly in the twigs towards the top of the tree. In some trees, indeed, as in pine, when planted close together, there is a rapid decay of the lower branches; but that arises from want of the stimuli of air and light, and consequent strangulation of the vessels at their union with the stem.

It is quite obvious that the sap, which is thus in the alburnum of the tree, will be in the state of most forward preparation the farther that it advances, because it will have dissolved the most of the store of the former year; and it is also obvious that it will come most forcibly and soonest to those plants which enjoy the highest temperatures, provided they be not so high as to indurate the external integuments of the parts.

There has been not a little of puzzling speculation about the way in which the substance of plants passes from cell to cell, and from vessel to vessel; and the same has also been found when the action of the air, upon the external tunics of plants, has been investigated. There are no perceptible pores in the walls of the cells, there are none in the vessels, and there are none even in what are called "pores" on the surface—these latter being found, on *observation*, to be simple *culs-de-sac*, lined with exceedingly delicate but still unpenetrated membranes. But truly there need be no puzzle about the matter. Of what magnitude are the pores in the coats of the blood-vessels that are ramified over the cells in the lungs of an animal?—and yet they transmit, or, if the word be better liked, secrete, carbon; and why may not the coats of vegetables do the same? The substances transmitted, or secreted, are water, and gases, and chemical solutions, perfectly homogeneous under the scrutiny of the most powerful microscope, if they be not mixed with foreign substances. They are, in fact, made up of ultimate atoms, the very nature of which precludes the possibility of our assigning to them any magnitude, how small soever; and if that which has to get out or in has no size, what need of puzzling about the size of the hole which admits it? These permeations by ultimate atoms seem to be the peculiar operations of nature's chemistry; and just because there are no holes in her filters she effects analyses, and thence forms compounds which no skill of man can by possibility imitate. The smallest portion of matter of which we can in any way, even with all our glasses, take cognizance, is a lump, and a great lump, as compared with those into which nature can divide a substance. How many millions of atoms, all capable of being differently acted on by light, are in the cup of a fine tulip!—and yet they all must have been elaborated, and elaborated differently, because different appearances can be produced only by different causes. How fine, too, must be those particles which scent the air for many yards, and many days, from the small corolla of mignionette, and yet each of those particles must have a separate physical existence, because it makes a specific impression upon the organs of sense. But the odours, the colours, and the tastes of plants, and the products of plants, are so numerous, that no arithmetic can sum them; and therefore the secretions must be very various, and probably all through membranes in which human scrutiny can find no pore. It is highly probable that all the remarkable changes in the nature and composition of the fluids, both of vegetables and of animals, which are known by the names of secretions or absorptions, are produced through membranes which, to our observation, seem imperforate. The terminations of the pulmonary arteries, and the commencements of the pulmonary veins, in the air-cells of lungs, have never been satisfactorily made out; and no passage of injected matter from the one to the other has ever been effected, which might not be much more easily explained upon the supposition of a rupture of the parts, or which did not, in fact, demonstrate that such a rupture had actually taken place. These structures cannot be examined in the living state; and they are so delicate that, with them, the moment of death and that of dissolution are almost co-existent. It is extremely probable that, in its passage from the sap-vessels to the returning vessels of the leaves, the sap of plants passes through such an ordeal in the margins of the leaf; and, also, that when the "proper juice," as it is then called, is changed into any new peculiar product, the passage is atom by atom.

Atomic action is a very wonderful thing; and the demonstration of that power which its Author has given to nature lies much in that province which terminates before human observation begins; and, therefore, we do not now, and, in all probability, never can, see any thing but the results. We can no more hope, we suspect, to analyze the apparatus by which a rose elaborates its perfume, a pine-apple its flavour, or a nettle its venom, than we can hope to ascend permanently in a fluid of less specific gravity than our own bodies, or be and not be at one and the same instant of time. Still the properties of these ultimate atoms are most wonderful. When the atomic action of water is lowered by heat, how limpid the whole becomes compared with ice! When but a little oxygen is mixed with it, the diamond is an invisible gas; take away the oxygen and it is the hardest and most brilliant of substances. When we meet with such an atomic change as that, within the range of our plain observation, what can we bring ourselves to regard as impossible in the atomic action of plants, or of any other department of nature?

Action of Leaves.

The action of the sap, as noticed above, begins at various times in different latitudes, different seasons, and different trees, but in England the average time of its commencement is February, and it continues till, on the average, about the middle of May, being most abundant and obtainable from all cut parts of the wood just before the leaves expand. This is, as it were, the preparation of materials to begin the labour of the year. During it there is comparatively little moisture or action in the bark; and, if the leaves be all plucked off as they make their appearance, the labour of the season is at an end; though if it be the habit of the plant to form buds in the bark it will push out numerous shoots there. Instances of that may be seen in those oaks, elms, and other trees in many parts of England, which are pollarded or polled, have their heads, and consequently their number of leaves, very much reduced, for the purpose of obtaining brushwood. Whether the total quantity of wood elaborated in the course of the season be, by that means, increased or diminished it is not easy to say, because there are tendencies both ways; but the trunk of the tree is by it converted into a sort of vertical coppice, the produce of which is periodically lopped off, and the tree immediately begins a new crop.

When by any means the leaves expand, the tendency of the sap to flow from wounds in the wood, and when they have partly expanded it ceases altogether. When it begins to diminish in the wood it shows itself in the whole bark of the young shoots, and in the inner bark of the older branches and stems; and as the quantity diminishes in the one it augments in the other. The quantity in the bark is never, however, so great as it was in the wood, and it is of greater consistence and viscidity, and does not flow so freely from a wound. During the whole of this second period it is most abundant between the bark and the wood, which are then very easily separated from each other; and, when the separation is made, the surfaces separated—and more especially those of the bark—are found covered with a semi-fluid, which is very mucilaginous in some trees, as in the mountain elm—and more saccharine in others, as in the fir. As the season advances more and more matter is taken in by the roots and other absorbent parts of the plant; the cells of the alburnum are more and more exhausted of their contents and reduced to woody fibre; and more of the altered sap, or "proper juice" of the tree, descends through the vessels of the bark, and is deposited between the liber and the alburnum.

As the season advances the quantity so accumulated acquires more and more consistence, becomes a sort of fibrous and granular, from the first rudiments of cells and vessels appearing in it; and in that state it gets the name of *cambium*, or that which has been changed—changed from the inorganic sap, which first appeared in the alburnum, to a substance capable of forming fibres and membranes. The process is gradual, and extends farther into the summer if the weather is cold and moist than if it is warm and dry. But in all cases there is a period at which it ceases to increase in volume; and after that it acquires consistency, or, as the technical phrase is, ripens. The ripening, that is, the formation of the cells and vessels, and the consolidation of their contents as a store for the following season, has a considerable influence upon the state of the tree in that season. The buds, whether for leaves or for fruit, are not brought forward till the whole addition of the year is made to the tree; and in proportion as that ceases earlier the buds are in better condition, and those which are to produce flowers and fruit more abundant. In proportion to the promise thus given, however, is the danger of a total failure if the early spring should be cold, and followed by severe weather. Of this the seasons of autumn and spring, 1830-31, afforded a remarkable instance.

As the wood ripens, vessels begin to form in it both from the new wood and the bark, and there is some difference in their structure as well as their functions. They do not convey so much matter as those vessels by which the sap rises in the wood, and they do not continue in action for so many seasons; and, consequently, they are fewer in number and collapse more easily. By the time that the ripening is at an end the cambium has formed into two parts; one for a new liber on the bark, and the other for a new layer of alburnum round the wood, of the tree; but there is a very considerable adhesion between these two, and they cannot be separated without difficulty till the new season be so far advanced as that fresh cambium begins to be between them. Thus the second part of the process of vegetation is, the progress of the proper juice from the leaves to the junction of the wood and bark, its deposition there in the form of cambium, the ripening of that cambium, its separation into new wood and bark, the formation of the new shoots of the year from the buds of the former year, and the preparation of buds for the year which is to follow.

By what new agency is the change accomplished? The organs are the leaves in the grand change of the sap into proper juice, and the respective vessels of the liber, and the surface of the alburnum, in the ultimate change of the cambium into bark and wood. The other parts are formed by local organizations.

The only agency which is added to the agencies employed in conveying the sap to the buds, for the evolution of the leaves, is light; and thus we may consider moisture, heat, light, and atmospheric air, as the only, or the principal, agents employed in the final process of vegetation. In this, as well as in many other parts of natural history, it is sometimes the plan to have recourse to electricity; which is much the same as if an Englishman, who did not understand some word of his own language, should go about to translate it into Greek, in the hope that it would thereby become more intelligible.

As the substance acted on, the agents and the result are, in some measure, known in this case; some notion at least may be formed of the action that takes place. Many parts of it are, no doubt, in the present state of our knowledge, altogether inscrutable; such as why one plant has the petals of one colour or number, and another has them different; why some trees produce resin, others gum, others astringent juice; why some yield colouring matter to the dyer, and others none. These and countless other questions of detail cannot now, and perhaps never can, be answered; but still we may know something about the general process by which the new matter is formed.

It has been mentioned that about ninety parts to one of the sap in the elm consist of water; and though in some plants it be much less diluted than that, in others it is much more. But the water, or, which amounts nearly to the same thing, the elements of water which rae found in soft vegetable matter—as mucilage and starch—do not amount to more than six-tenths; in oak-timber they are less than a half; and in good dry elm, perhaps, about a half must be the quantity. Eighty-nine parts out of the ninety of water have, therefore, to be got rid of before the sap can become hard wood or dry bark, and much of it before the said sap can become a vegetable substance at all. The most extensive operation of the leaves, therefore, is the giving out, by evaporation, of a vast quantity of this water. Dr. Woodward found that a sprig of mint, only twenty-seven grains in weight, absorbed 2558 grains of water in seventy-seven days, and that its weight increased only fifteen grains. Supposing the increase to be all water, the quantity perspired by the surface must have been 2543 grains; but if the mint was vegetating properly there must have been some carbon in the addition, and therefore the perspiration must have been greater than that stated. A plant cannot be very well experimented on in a state perfectly natural to its growth, and therefore the only certain conclusion to which we can come is that plants, upon the average, give out by far the greater part of the water which they absorb, so that the water is more an assistant than a principal in the process of vegetation. Along with the perspired water there appears to be a very small proportion of feculent matter given out; but of which of the textures of the plant that is the waste, or whether it be something not fit for the purposes of vegetation which had been originally absorbed with the water, has not been ascertained; it may be partly from the one source and partly from the other. Of this, however, we are sure, that nothing can enter the absorbents of the plant unless in a state of solution, and consequently no substance can have to be discharged from plants, or can enter into their composition, which is not soluble in water.

The earthy substances, such as the silica, which is found on the equesitums, and also in the epidermis of some of the grasses and reeds, are the most obstinate substances that have been detected in plants; and the quantity of these is so small in proportion to that of the water that passes through the plant is adequate to the most perfect solution of every thing which the plant can contain; and the very great excess of water which there is above what is absolutely necessary for that purpose, with the great minuteness of the vessels through which the whole volume passes, insure a much more intimate union of all the ingredients than could, perhaps, be obtained by any other means.

But the leaves are not always exhalents of the surplus water of the sap. They are stationary in some conditions of the atmosphere, and in other states of it they act the parts of absorbents, and that with so much rapidity that a plant which has been drooping almost instantly looks fresh when the leaves are watered.

The whole both of the absorbent and the exhalant functions of the leaf are most probably carried on in the sap-vessels; and it is not impossible, nay, it is rather probable, that the very same tissues which allow the water to pass by evaporation outward, allow it to pass by absorption inward, when the quantity of sap in the plant is not adequate to saturate the absorbing matter in the cells and vessels of the alburnum. Independently of the more immediate action upon the leaves, we should be led to infer that the young twigs would suffer most from drought or any other cause affecting the free action of the plant. Their substance is more delicate in itself; and experiment agrees with hypothesis in determining that the sap becomes more heavy and viscid, and therefore more easily arrested in its course, the farther that it is from the root. It may be, too, that after the process of vegetation is fully established, some part of the moisture may be evaporated through the bark; and in the ripening of the wood in autumn there is little doubt that a part goes off in that way; though some also must escape by the leaves, after the fine tissues in their margins, which unite the sap and the proper vessels, have become too much indurated for allowing any more matter to pass from the one to the other. This is also in part increased by the augmentation of the new layer, and the consequent constriction of the partially emptied cells and vessels of the alburnum from the resistance of the air.

But water is not the only product which the air separates from plants; for during the whole process—from the first swelling of the matter in the cells and vessels, to the entry of the proper juice into the proper vessels, and probably after—plants give out carbon, which, uniting with a portion of the oxygen of the atmosphere, forms the same volume of carbonic acid. All the effects of that upon the plant are not very well understood; and as the quantity of carbon which the plant takes in is very small in proportion to the water, as compared with the ultimate products, this part of the process might almost seem to be labour to no purpose; but, as is the case in the germination of the seed, we know that this formation of carbonic acid augments the heat at the active surface, and aids in assimilating the inorganic alburnum of vegetables to a substance more fitted for active vegetation. In this part of the process, also, the vegetation of the plant differs in nothing from the germination of the seed, and it might, like that, be carried on in the dark.

But there is another, and, as it should seem, a very important agent—the action of light—upon which many of the nicer operations and results in the plant depend. The most remarkable chemical result—that is, the most remarkable result that comes within the province of human chemistry—as produced by light, is the separation of oxygen. Simple as this process may appear, it is probably to it chiefly that we are indebted for the beauty, the odour, and the pungency of the vegetable tribes. The nitrogen of the air has no effect in common cases; and the changes produced on the atmosphere, by the few plants that do contain nitrogen in their substance, have not been observed; and therefore we have no evidence that nitrogen has any more efficacy than that surplus part of the absorbed water which is given off by perspiration.

When, therefore, we review the whole process we find that the evaporation of the water thickens the juice, not at first, however, to a granular substance, but to a mucilage; that the oxygen of the air separates a portion of carbon, but does not appear in any way to enter into the composition of the plant; that the caloric rendered sensible by the union of the oxygen of the air with the carbon of the plant, in some way favours the process of vegetation, but whether by simply counteracting the cold produced by the evaporation of the water, or by any other means, we are unable to tell. The plant does not spontaneously furnish us with the information, and as a living thing we question it in vain by experiment, because that which we seek may be lost or destroyed in the very first step of our process; and the action of light is more singular still in its effects, but more inscrutable in its operation.

The peculiar products must all come from the proper juice of the plant; and each must be separated from it by an organization fitted for the purpose. Some of these appear to be owing to peculiar combinations of acids, some to oils, and some to peculiar principles, partaking apparently of the nature of alkalies. Of the flavours some, as in the blossom and even the leaves of the peach, and especially in the kernel of the bitter almond and of that fruit, are owing to *hydrocyanic* or prussic acid; and probably, when the subject comes to be examined by improved analyses and improved apparatus, much of the colour which is not explainable upon the well-known tendencies of the acids to produce red, and the alkali to change that in succession to blue and green, may be found to depend upon iodine: but these matters have not yet become subjects of very legitimate philosophy in the schools, and therefore they are unfit for a merely popular sketch. The operations that take place in the vegetable kingdom are highly interesting when known ever so little;

and they are so many, and so universally diffused, that we every day trample more real knowledge under our feet than we have collected on the shelves of all our libraries.

We had almost forgotten to mention two points connected with this sub-section which are rather important: the one is the healing power that there is in the cambium; and the possibility of the exertion of that power at whatever part of the tree there are leaves. From the experiments of Du Hamel, Knight, and some of the other eminent investigators of the subject, it appears that the cambium, and even the wood itself, will produce bark to heal over a wound, if the atmosphere be excluded; and that in those cases the process is carried on by a sort of granulation not very different from that which takes place in the case of an animal wound. When the atmosphere has acces to the wounded surface, there comes no healing but from that part of the cambium which is in connexion with leaves. If the bark be removed in a little ring round a small patch from which no leaf-bearing shoot issues, the new bark will come from the outer circumference of the ring, and not at all from the insulated patch, which will be in time pushed off by the uniting of the new bark under it; but if there is on the patch a twig bearing leaves the new bark will form round the circumference of the patch; and, though the progress of healing will be slower there than from the external circumference of the ring, still the final cicatrix, by which the wound will be altogether healed, will be in the form of a ring at some distance from the twig.

The other point is the change of white leaves to green, as noticed by M. Senebier. When a leaf has been blanched or rendered white by the absence of light, and is then exposed to the light, those parts of the leaf which, in their ordinary state, give out oxygen the most readily, are the first to become spotted with yellow and then with green. For this remarkable effect of light, Senebier attempts to account on the supposition that the light decomposes carbonic acid in the parenchyme, or pulpy matter in the cellular tissue of the leaf. But we are not aware that carbon can, under any circumstances, impart colour to that which is colourless; besides, there is less carbon in leaves than in the solid parts of plants; and what is there is in the vessels and walls of the cells rather than in the parenchyme. The coloured matter is a gum or resin usually mixed with a considerable portion of alkali;—potass, for the most part, in land plants; and soda in marine ones, or in those that are indigenous upon soils strongly impregnated with salts, of which soda is the base. These last have generally more or less of a brown or coppery tinge, and many of them, as the common dulse *(ulva edulis)*, become green when broiled. That this greenness is occasioned by the extrication of a portion of muriatic *(hydrochloric)* acid is very obvious, not only from the analogy of the same action in vegetable infusions, but also from the fumes that arise during the broiling, and from the alteration in the taste of the plant. If, however, the same plant be for a time soaked in water and then exposed to the light it dries red; and if the soaking be continued long enough the plant dries white or transparent; and, though it may then be made partially red by an acid, or yellow by an alkali, the colours are merely a trace; and nothing approaching either the original coppery hue, or the green after broiling, can be effected.

Now these facts prove that there is in the plant under consideration a colourable matter, not carbon (for the carbonic acid, if it existed ready formed, would pass off in the fumes before the muriatic); and that, though this matter be changeable into various shades, according as the acid or the alkali prevails, yet that it is independent of them. We know that aquatic plants contain iodine, to which their colour is unquestionably owing. In the state of hydriodide of soda (combined with soda and hydrogen) iodine is of the most beautiful purple; and the liquids that hold it in solution are capable of undergoing various shades of colour. With the exception of chlorine all the acid principles (that is, all the acids that contain oxygen,) are expelled both from soda and from potass by iodine.

It would not be difficult upon these facts to build a theory of the colourable matter of plants, and to state that the general green of the vegetable world is owing to the union of iodine with the alkalies; and that all the other hues arise from various modifications of that compound, by various portions of those acids and oxides, and their combinations, which exist in the coloured part of plants. But knowledge is wanting; and in the absence of that the plausibility of a theory would be no evidence of its truth.

Nothing is more easy than to make theories on subjects of which every body is ignorant, and that very facility has all along been the bane of science. The subject is curious, however; and, as it might elicit something important in the art of producing colours and rendering them permanent, it is worthy of investigation—the more so that beautiful colour pleases a greater number than any other kind of beauty, inasmuch as it is felt without thought.

SECTION IV.—FUNCTIONS OF INDIVIDUAL ORGANS.

From the extent at which the general process of vegetation in a tree has been considered, and the reference which has been made to all the parts of that which are concerned in the making of additions to its own structure, the present section may be confined within very narrow limits. The functions of the root, the trunk, the buds, and the leaves, have been already noticed; and thus the chief subjects that remain are the flowers, from their appearance in the bud to the maturing of the seeds, which is the ultimate object in that part of the vegetable economy.

Flowers are the most beautiful objects in nature, and they are never deceiving; for if the flower is beautiful, and at the same time fragrant, we may expect little deleterious in the plant: on the other hand, if the flower be offensive to the eye, and more so if it be ungrateful to the smell, caution is required; and, however tempting any part of the plant may seem, it should not be eaten in the raw state. The forms, colours, scents, and savours of flowers are so varied, that they cannot be treated in a general manner, so as to furnish any thing like knowledge.

The petals of flowers, which come forward in an envelope of *bracteæ*, or in the *calyx*, are always more or less green, have the tint of the young parts of the plant, though generally in a faint degree, when they are first perceptible; but as they unfold themselves to the light they acquire all those hues which make the fields and the gardens so gay. Apart from the action of the solar beams it has been often proved by experiment that there is a colourable matter in the infusions of some plants, even though they be perfectly colourless when obtained. Upon that matter acids have the most decided primary effect, and turn it red, while the alkalies change it through all the shades of purple, violet, blue, and green, till they end with the destruction of it—in the case of chlorine. The action of light renders the colours of flowers, in general, more brilliant, but it is not so necessary for producing them as it is for producing the green of the leaves; and when many of the very exquisitely-coloured flowers are exposed to the direct rays of the sun they are injured. The fact is that there is no such chemical action of light in the petals of flowers as in the leaves of plants. They do not give out oxygen by the decomposition of any of the alkaline salts; and thus, if the light does in any case deoxydize them, the effect is merely a loss of colour. It is for that reason that the petals of flowers, in a natural state, rarely have any shade of green; but how the acids which they contain are so tempered to the colourable matter as to produce every shade, from the purest white to the most intense red, it is not very easy to see.

That the colours are much changed by cultivation is true, but we do not know all the means by which that is effected. The total colour, though not the absolute shade, seems to depend something on the general character of the sap. Where moisture is very predominant the flowers are paler than where it is rather in deficiency; and where the action of the leaves lessens the flowers acquire a rusty or reddish tinge, obviously from an excess of acid in the sap with which they are supplied. Those plants which contain the greatest quantity of alkali in their ashes have the flowers yellow, or blue, or greenish; and those that have an excess of acid have them more orange or red.

New varieties of colour in very many cultivated flowers are produced by different inoculations—as, if the pollen of a yellow flower be applied to the stigma of a crimson one, the colour of the flowers from the seeds may be presumed to be scarlet. Much of that kind of inoculation goes on naturally in places where many flowers of different tints are growing near each other. That is effected more readily the more that the plants resemble each other in their structure and habits, and most of all when they are all of the same genus. Dahlias, pinks, carnations, and many other flowers are in that way varied in their colours almost without limit. It has been supposed that watering plants with coloured solutions might change their colours; but that is not the case: if the colour were to be changed in that way the flower ought to be the part least affected, because it is the part which differs most from the other structures of the plant; and the more coloured that it is, and the more susceptible of changes of colour, it always differs the more from these.

The sap, or nourishment of the flower, comes from the common sap of the plant, but in the roots of the petals it undergoes those changes which gave them their peculiarity; and the principal chemical change is that which has been mentioned—less alkali, and less of the alkaline carbonates.

The absence of these is closely connected with the odours of flowers. These odours depend generally, if not exclusively, upon essential oils, which are soluble in alcohol, and volatilized by heat. The elementary part of all these oils must be contained in the general sap of the plant, and it is exceedingly probable that there is a rudiment of them in the seed; sometimes, indeed, the seed has much more scent than any other part of the plant. Now, as there are always alkaline solutions in the sap, and as those oils are soluble in those alkalis, the scent is not given out where the alkali is in excess. That the scent of flowers is chiefly seated in the petals is well established, because in those flowers in which, by culture, the stamens and pistils have been transformed into petals, the odour is retained and sometimes increased. This odorous matter is always inflammable, very diffusible through the atmosphere, and, speaking generally, it abounds the most when the action of the sun is most powerful. The taste of flowers, and also of the pulp or flesh of fruits, appears to depend on the action of light as well as their colour and odour. The greater the light and heat are the taste is the more pungent. When deprived of it some plants become mild and others tasteless; but if they be made again to grow in the light their flavour returns. We have sufficient proofs of that in every plant that can be tasted. Turnips that grow far apart have considerable flavour; those that are huddled together till the lower leaves be stialated have little or none. Apples which are from rank-growing trees, and hidden by leaves, are insipid compared with the smaller ones on a tree round every fruit on which the beams of the sun can play. In a dull and cloudy season the whole of the vegetable productions are insipid; in a clear and sunny one they are rich and vinous. Even heat does not compensate for the absence of light or the partial diminution of it; for fruits which are grown under glass are not so racy as those that are produced in the open air, supposing the kind and the degree of ripening the same; and those which are forced by steam, though they may be more pleasing to the eye are not so rich to the taste as those that are produced in dry air—they have not the free light or the free breath of heaven—the light comes to them, through the floating particles of steam, " shorn of its beams," as it does through a lightly drizzling fog. Whatever, therefore, may be the advantages of steam in forwarding the mere vegetation of the plants (and the juice of these, too, must have less of the elements of raciness under its influence) the fruit ought to be ripened in dry air. To make the plant watery in all parts of it must be the effect of steam; or if not (and that will indeed have nearly the same effect upon the quality) the quantity of action must be less in proportion to the size of the plant. Evaporation cannot go on in an air saturated with steam, and disposed to deposit moisture upon every surface in the least degree colder than itself; but if the action of the plant be diminished, the giving out of oxygen, and the consequent heat at the transmitting surface, must be diminished; and thus, every way that it can be viewed, the plant must either take in less moisture at the root, or that moisture must remain in the substance of it. Something, no doubt, must depend on the natural habit of the plant. If it grow naturally upon arid places, and depend for its supply upon the absorption of its succulent leaves, steam may be the very element for it; and thus the fruit of a cactus may come to the highest perfection, where that of a forced peach or cherry would be insipid or even nauseous.

But though the colour, the odour, and the flavour of flowers be very delightful in themselves, and very fine instances of that inscrutable chemical agency which the beams of the sun exert upon the earth, they are accidental, in so far as regards the grand purpose of inflorescence—the preparing of the seeds of new plants. Indeed, that cultivation which labours to improve the colour of flowers generally renders them less productive, if not altogether barren, by changing the organs, upon which production depends, into gaudy but barren petals. There is no bad moral in that; but, as it is one which will suggest itself to any body, it need not be stated.

The production of flowers, and the maturing of seeds by means of those flowers, though unquestionably the most interesting part of the physiology of plants, is by far the most mysterious; because it sends us back to the very extreme of origin, where the process and the product alike elude our keenest observation. At this point, and it is the important point, nobody can know any thing; and therefore all things may be said with equal truth or falsehood. "The flower-bud upon the perennial plant," say some, "is changed leaves;" and, say others, "When the annual or the biennial plant can produce no more stalks and leaves it produces flowers." A production which is half leaves half flower—as the cone of a pine pervaded by a shoot, or cone on the one side and wood and common leaves on the other; or, a rose with the petals perfect, but all the central parts changed into common green leaves, is appealed to as evidence of the first; while every field affords evidence of the second. But the Indian figs *(cacteæ)* bear very handsome flowers, having petals and stamens very numerous and very regular, and, on some of the species, followed by wholesome fruit; and yet there is not upon the parent plant any thing that can be called a leaf—the nearest common similitude to it is that of a bunch of cucumbers all fastened together in a very fantastic manner. The petals and stamens there cannot be changed leaves; and they have nothing in their arrangement similar either to the stems (or fronds) or to the prickles with which these are armed. All that can be said with certainty is that all the parts of a plant are "changed inorganic matter;" and as to what any of them *would have been*, if it had not been *what it is*, one conjecture is just as good as another. With very little alteration of their *original* substance the blossoms on a rose-tree might have been a diamond and a glass of water; and thus to say that flowers are "changed leaves," is about as satisfactory as to say that the whole vegetables on the face of the earth are "changed diamonds and water." We distinguish the flower-bud from the leaf-bud, even while they are still unopened, and even in those species in which the winter envelopes change into green leaves; but the flower must be in the bud before we can see it, and therefore all that we can know about its origin, or the causes by which it is originated, must be derived from observation of the circumstances under which plants have or have not greater tendencies to produce flower-buds than leaf-buds.

Now that is open to every body's observation. The less numerous and vigorous the leaves, there is the more tendency to flowers and fruit; and this holds good till the want of leaves becomes a disease, and then the tree languishes and decays. What are the circumstances that tend to produce an abundance of leaves? A rapid and constant supply of pabulum by the absorbents; and the consequences are, the absorption of more carbon, and the giving out of more oxygen to the light. The plant thus becomes altogether more alkaline and more carbonic, and therefore the whole sap of it is less adapted for the system of fructification, for which carbon and alkali are not so much required. When flowers are wanted in greater abundance, this habit must be lessened; and nothing tends so much to lessen it as the induration of the leaves. Accordingly, it is only at a certain state of dryness in the plant (to be found by observation for any individual species) that the rudiments of flowers begin to be formed; and, as the flowers and the fruit advance, the dryness (if the leaves have preceded the fruit in development) increases. Hence there are many fruit-buds in a dry autumn; hence plants seldom fruit, except grafted ones (and they are old) in their young and succulent state; hence over-manured corn runs to straw and does not ripen or even fill; hence potatoes in very moist soils are waxy and want farina; and hence, in short, very many of the facts that should, and do, guide the cultivator.

Heat is the principal cause of this dryness; and hence many of those climatal habits of plants which otherwise would appear to be capricious. Many tropical plants will grow vigorously, not only in a hot-house, but in the open air, which will never ripen a single fruit or even expand a blossom. The common laurel does not bloom on the Scottish mountains, neither does the elder ripen its berries. Upon the very same principle the cloud-berry, and the little sweet bramble of Lapland, will not bear fruit in our gardens, or even live, and the more we cherish and shelter them the more sickly they are. They are, as one would say, deceived by our inconstant atmosphere. The warm days in spring call them into action, and the long night chills them. In their native regions there is very little night during the seven or eight weeks that they are active; and when the winter comes there is no snow to mantle them, even when the thermometer is down nearly to zero. On their native mountains their temperature is never below 32°, whatever may be that of the atmosphere over the snow. It is upon the same principle still that Alpine plants will not flower in low and warm situations, more especially in crowded cities and their suburbs. In that case there may be some effects from the ammoniacal gas and other deleterious matters with which the atmosphere is charged; but these do not produce the whole effect. Such are some of the external causes that affect the operation of flowering.

That all the nourishment which the flower receives from the plant comes through the peduncle, from the sap, and not from the proper juice after it has been acted on by the leaves, is generally understood; and all are agreed as to the functions of the fertilizing organs. But there have been differences of opinion about the petals. It is quite in accordance with human views that a part of plants upon which nature has bestowed so profusely her colours and her odours should have a most important use; but yet of what use in the economy of nature is the pulp of the peach, the oil of the olive, or the juice of the grape? The real seeds and they are matured together, and the seeds vegetate just as well when they are immediately removed from these as when they remain till the pulp be wasted by dissolution. From the circumstance that the stamens, in those plants which have them *perigynous* or surrounding the ovary, are more or less attached to the corolla, it has been supposed that a juice adapted for producing the fertilizing matter is elaborated from the sap by the petals, much in the same manner that the proper juice of the plant is elaborated by the leaves. But there are at least doubts of that, inasmuch as even in perigynous flowers the stamens, though they sometimes adhere to the petals and sometimes to the ovary, always have their real insertions below that, and derive their vessels immediately from the peduncle. That the petals derive their sap from that of the alburnum, and not from the proper juice of the tree, is evident from the fact of their having spiral vessels, which never make their appearance in the bark; and, as the formation of the flower and of the leaf happens at the same time, whichever of these may be the first that is developed, it is not in accordance with the general law of vegetation that the one should be elaborated from a juice prepared by the other. The flower must therefore be considered as a separate organization, of the immediate cause of whose appearance we are ignorant; and it is equally probable that each of the parts of the flower, the calyx, the corolla, the stamens, the nectary (where there is one), and the pistils, should have different organs for their production. It is farther against the supposition that the petals prepare the juice out of which the pollen is formed—that the petals are more numerous and vigorous in those flowers that bear no organs of fertilization—that they are wanting in some fertile flowers—and that in those species which have the fertilized and the fertilizing organs upon different plants or in different flowers, that which has not the stamens sometimes has the most decided and the best-developed petals.

It has been already noticed that there is less alkali and less carbon in the flower than in the other parts of the plant; and in addition to this the flowers, instead of giving out oxygen under the action of light, absorb it under all circumstances. How this oxygen may act upon the different parts in preparing them for the performance of their functions it is not easy to say; but there is one effect of it which is easily observed, and which tends farther to confirm the fact of the necessity of more heat for the fertilizing and maturing of seeds than is required for the common structures of plants. Heat is thereby produced to such an extent that when the anthers are nearly matured the cup of the flower of some plants has, even in the temperate climates, 12° more of heat than the atmosphere; and that in tropical countries the difference is sometimes as much as 50°. These differences are most apparent at the time when the day is the hottest; and thus, in as far as the fertilization is concerned, the climate is made hotter in every zone by means of the flower, and that, too, at the very time that of the leaves of the plants, if they are duly supplied with moisture, have their heat least, as compared with that of the atmosphere.

This part of the subject is worthy of more observation than has been bestowed upon *it;* because the whole rationale of the colour and the scent may be connected with it. If there were not some removal of matter from the surface of the flower, when strongly acted on by the sun, then it is agreeable to the general law of the soft coverings of living things that the surface would become indurated. The essential oil which forms the scent evaporates very easily; and thus the surface may be kept in an active state, while its temperature is higher than that of the direct beams of the sun. It is not a little singular too that a flower in England, while the plant upon which it grows is a positive source of cold, should have the power of producing for its anthers a climate equal to that of the middle latitudes of Spain; and that in the tropical countries the plants should produce a heat for the same purpose which to man and to many of the animals would be intolerable—a heat 25° or 30° greater than that of the blood in healthy states of the body; and of course a heat which would soon produce deleterious consequences in the animal structure.

When the comparatively small increase of temperature which is in general required for the expanding of flowers, above that which the general process of vegetation demands, is considered, it is easy to see how much more elaborated into oils, and other volatile products, the pollen of the anthers on the stamens must be than even the matter of the flowers. The fertilizing quality of that pollen is a mystery, as well as the fertilizable quality of the stigma to which it is applied; but the pollen itself is so much elaborated that in some cases it does not appear to have much more specific gravity than hydrogen gas; and thus it easily floats, or is carried upon the hairs of honey-seeking insects until it reaches its destination, whether in the same flower, in a different flower upon the same plant, or a flower upon a different plant; and thus, except in times of extraordinary rain, the purpose of nature is accomplished in the securing of a succession of the species. The multiplication, too, is very great. The produce of the wheat-fields in England if wholly sown would, in a very few years, cover the whole earth with that grain. That, too, is far from being one of the most productive of plants. Some of the palms have 8000 fruit in a single bunch; one spatha of the male date often contains more than 10,000 flowers; and those upon one plant of some other species amount to nearly a million. Nor is it in what we are in the habit of considering the nobler families of the vegetable kingdom that we find those high productive powers. If all the seeds, or sporules, or whatever they may be called, that are in a single puff-ball *(lycopodium)* two inches in diameter, were to grow, the produce would be many millions, and lycopodiums would, in a short time, usurp the place of every thing else. But those vast powers are regulated by circumstances which are as certainly established by the Creator as the powers themselves; and thus every tribe is produced in the fittest place and season, and that which is not required for any one tribe is useful to some other tribe, animal or vegetable, or to man. Man boasts much of his wealth and his skill; but, were it not for the active principles of living nature, which he may direct but cannot originate even in the humblest weed, his wealth would have no existence, and his skill no value.

SECTION V.—MOTION, SLEEP, AND DECAY OF PLANTS.

The motions and the sleep of plants are matters more of curiosity than of use. The motion bears no resemblance to animal motion, but is always produced by some external circumstance which is the real agent. Their sleep, or those foldings up of the petals or the leaves to which the name of sleep is given, has not any resemblance to the sleep of animals. The plant is passive except when something external acts upon it; and thus a plant can no more be said to be fatigued when it grows rapidly, or is agitated by the wind, than a stone can be said to be fatigued when it falls to the ground, or the ocean when the storm lashes it into waves. Indeed, the rest of the stone may be called its sleep, and the calm which follows the storm the sleep of the sea, with as much physical truth as the drooping of a plant, or the closing of its leaves or petals, can be called the sleep of the plant. The notice of those motions and apparent reposes is more a part of the particular description of those plants in which they appear than of general physiology.

It is a general law of nature that of every organic being there must, at some time, be an end—that that which is made up of parts must sooner or later be resolved into those parts; and such is the case with plants. When the function is performed, the organ is removed from the living world. Some of the finest corollas last but for a few hours; leaves remain for their season, or their two or three seasons; the great chestnut-tree of Tamworth is *said to* have lasted for 950 years; some palms, if casualities do not befal them, make a nearer approach to immortality; but they all fall at last, and their remains feed their successors.

In the boles of large trees of very advanced age, there are often singular struggles for life. In some of these, yews for instance, the very vigour of the growth seems to hasten the decay of part of the stem. Those branches which are nearest the earth are the least exposed to atmospheric action; and the efforts which they make occasion those gnarls and clumps that are so abundant in those trees. But they push inwards at the same time, and by that means compress the vessels in the central parts and destroy their action. If the upper branches be feeble, as compared with the under ones, an entire excavation is the result; but if these branches be strong each of them is able to maintain its state of growth; and in those cases the lower part of the trunk appears like a bundle of rods in a case. In the churchyard at the picturesque village of Loose, in Kent, there is a fine old yew, with a trunk nearly forty feet in circumference, and a vigorous head more than sixty-four feet in extent, which affords a good specimen of this resistance of decay along certain lines diffused through the trunk. Some of the other *coniferæ* have the same habit; among others rfolk Island pine; but the durable parts in it efly knots, which are found dark and resinous decayed trunks.

CHAPTER VI.

CLASSIFICATION AND NOMENCLATURE OF PLANTS.

ARRANGEMENT is in a science which embraces many details what order is in the management of the common concerns of life; and, therefore, it would at first seem rather singular that, though the living productions of the world were probably the first objects of which man possessed or even desired the knowledge, there should yet not be, at the present time, any one arrangement, either of animals or of plants, to which there are not very many objections, and which does not, in but too many instances, darken and confuse that very knowledge to which it professes to lead. At the first thought of the matter, one is very apt to suppose, that however difficult or laborious it may be to come at the knowledge of the individuals, where they are so very numerous as the living productions of nature unquestionably are; yet that there should be nothing more easy than the arrangement of them into classes, after they are once known. In the physical sciences there is no such lack or imperfection of system; and yet they have been arrived at by laborious experiments or by intricate calculations. In astronomy, the system is nearly perfect; and few of the new facts jar with what are considered as the established principles in the sciences of solids, of liquids, or of airs. Chemistry, though but a thing of yesterday, as it were, has a system, tolerably good as far as observation and experiment have gone; and, though there be debatable points in it, the mode in which the earth itself has been elaborated and worked into its present condition has a good deal of the semblance of a system. Now, in all, or in most of these, there is a great demand for mechanics and for mathematics; and in some of them there is a necessary reference to long periods of history, and even a speculation anterior to the period at which any thing that can be called history began; while in the study of nature we have nothing to do but to use our senses, and might know the habits of animals and plants, although we had never solved a problem or analyzed a compound; nay, though our historical knowledge did not extend beyond the period of our own observation. Whence comes it, that that which seems to require nothing but the plain and honest exercise of our natural faculties, should remain so stubbornly behind that which seems to drain our other knowledge to the very dregs, and sometimes dregs and all?

One reason is, that incomprehensible something in action, which, in separate existence, is to our comprehension nothing, to which we give the name of *life*. It is always wiling us away from that which can come within the cognizance of our senses, and leading us in a vain pursuit after that which cannot. We are in a worse predicament with it than the dog in the fable was with the shadow—we drop the tangible in a vain attempt to catch at the invisible. The modes of life are all of life that we can know; and, as in plants the living subject is a still and silent thing, all that we can know of the life of vegetables is the mode in which they develope their own organization. Even there we have much to embarrass us. As has been stated in last chapter, the vegetable tribes would remain inert in the seeds till the substance of these mingled with the mass of inorganic matter, if they were not acted upon by external agents. That action continues during the whole life of the plant, and the developments of all the parts is so much modified by it that unless we, with very great care, average the appearances of the plant on all soils, in all climates, and at all seasons, the character that we observe is a compound one, of which some of the parts belong to the plant as a plant, and others to the circumstances in which it has been placed; and to estimate these in a manner even any thing approaching to satisfaction, requires a very nice and discriminating analysis,—an analysis rather too nice for the majority even of those who turn their attention to systems. This cause of difficulty is felt in the classification of animals as well as in that of vegetables; but among what are called the higher, or more perfect animals, it is not quite so perplexing.

Another cause of difficulty is the uncertainty that we have as to the known and the unknown qualities or properties of plants. Compared with the number of species, the number of properties that are known is remarkably small; and, of very many of those that are the most curious, all that is known is obtained from a dried specimen, or even a dried portion, which conveys about as much information respecting the habits of the living subject as a pickled herring does of the habits of that fish.

A third, and probably the chief cause of the difficulty consists of our ignorance of the relations which the different properties of plants have to each other. In some instances we find that there is a correspondence in several characteristics; but the cases in which there appear what we would call contradictory characters are much more numerous. Thus, that they shall not form lateral buds, is a very general character of the *coniferæ*, or cone-bearing trees; and it accords with another character—the parallel straight vessels in the leaves, and also with the easy cleavage of the timber. But those characters must not be supposed to have any absolute and invariable relationship, for the *arbor vitæ*, and some others that have cones, and the *pinus variabilis*, which is a fir, can put out lateral buds; and the wood of the larch is much more difficult to split than that of many trees with reticulated vessels in the leaves.

These anomalies render it extremely difficult to get a proper nomenclature; because, take what character we will, as the one upon which we are to found the name, and with it the order or the other division, we always meet with some species that wants that particular character, and which yet has so many of the others, that to common observation it seems to belong to that very portion of the arrangement from which it is excluded by the name.

Besides the difficulty there is in finding appropriate significant names for orders, or genera, there is difficulty in the names of individual plants. That, in part no doubt, arises from the ignorance in which mankind were of the true nature and qualities of the plants, at the time when the names were first given to them. That the name should be one sound, or combination of sounds, rather than another, proves that, in very rude and ignorant states of society, men must have had some reason or other for the application of the name in each class; but as the local names given to the same plant are not only different, but different in meaning, in cases where we can catch a glimpse of that very vague and unsatisfactory meaning that we get by etymology among nations that speak different languages—and as they are also different in different districts of the same country, where, pronunciation apart, the language of ordinary intercourse is the same—we are not permitted to conclude that they have been applied with any knowledge further than that of the general external appearance of the plant. We do not even know to what stage of the vegetation the name applies; though, in plants that are useful, there is little doubt that all the local names have been applied to the part used, and that all the other parts of the plant have been considered as merely auxiliary to that, and have hardly got any names till the people began to seek for renown by showing off in something like a philosophy of them. Thus with us the cereal or corn grasses, and the legumes, are all named after the seeds; and when the name is mentioned, it is the seed only to which in common speech we refer. When we speak generally of corn or pulse, or even when we are particular, as when we say "white wheat," or "Windsor beans," we never mean any thing but the seed; and if we wish to allude to the plant of which that seed is the production, we always add another word expressive of that—the word stalk, or plant, or something implying the same meaning.

With those names that have been given in what we not improperly call the "middle ages,"—as with the nations of western Europe they were intermediate between ignorance and true knowledge,—the case is not improved. At that time there were many superstitious qualities attributed to plants, and names given in consequence, some of which are ludicrous on account of their absurdity, and others absolutely revolting from their profanity. The names that are connected with the exploded machinery of "witching and diabolrie," are sometimes amusing. Such names as "Our blessed Lady's milk-thistle," and "pigeons'-grease," may be allowed to pass muster; but it is somewhat too bad to call a plant "The Holy Ghost;" nor is the matter much mended by the *scientific* name, "Archangelica;" and when the "pigeons'-grease"—the common vervian *(verbera)*—is called "the *holy* herb," that must be an abuse of the epithet. These were, however, it will be said, the times of ignorance and superstition, and we must not expect that the folks who lived then could be wise above what they knew.

Well, how stands it with the nomenclature of the present day? Why, if it be not so apparently impious, it is manifestly as absurd. Very many of the new plants, and not a few of the genera, as well as some of the orders, are called after human beings; and there is even a terminal distinction to let us know when the name is the reward of labour and when it is purely honorary: the radical part of the word may be English, or German, or Russ, or any language, however unmouthable, the users of which have names, and either find out plants, or win the favour of those who do; and then comes the terminal *a* for the discoverer, or the *ana* for the honorary attribute. It is all very well that the discoverer of a plant should have the merit of his discovery; but it is rather too bad that the fact of having been first seen by such an individual should be the only information given by that name, which, if it is to be of any use at all, should be a key to the general character of the plant. The discovery of the plant is a something; but, as contributing to general science or useful knowledge of any kind, it is the smallest something that can by possibility be imagined; and if all that is known about it were to stop there, the discovery would not be worth the having. As to "complimenting" a patron of science or any other influential person with the name of a plant—perhaps it should rather be said, complimenting the plant with his name—it is not easy to see how it differs from a farmer calling a calf or a pig after his landlord, or an author calling a book on astronomical observation, "*Southiana*," in compliment to

Sir James South; or, which is perhaps nearer the point at issue, my calling this book "*Browniana*," for which that most profound botanist would, I dare say, not be over and above thankful. But it is not to the lords and labourers of the vineyard alone that the supposed honour is done; those who know and care little for the study, come in for their share; and a story (whether true or not is another matter) is told of a certain "*nomifactor*" (that is about the word) who complimented his wife with the name of as many pretty flowers as would have formed a nosegay—although her only recorded labour in the science—soups and salads, pickles and preserves, of course excepted—was the destruction of *a hortus siccus* in his absence, in order to prove her thrift by selling the paper to the snuffman.

It is recorded that the first man gave names to "the cattle, and the fowl of the air, and the beasts of the field;" and really it is to be wished that he had extended his nomenclature to every natural production, and all their localities; for "a commodity of good names" is sadly wanted in every thing else;—in botany, in zoology, and in geography. In the latter science it is easy to find some Lord of the Admiralty who may or may not have been "registered to fame eternal" in any other way, standing monumental some five hundred times over, in mountain, promontory, bay, creek, strait, or stream, amid the desolation of the polar ice.

This absurd nomenclature (and it is the more absurd and the more reprehensible the greater the knowledge of those who practise it), which either conveys no information at all, or conveys information which has nothing to do with the nature of that to which it is the index, leads to very much of the uncertainty that is felt in the classification of plants. Names that have no meaning are as completely equal as names that have a perfect identity of meaning, and may be made to change places in any way without violence to congruity or propriety of any kind; for all the transpositions and transmutations that can be made among nonsense, come not within the limits of sense, and therefore can, in themselves, do that neither good nor harm. But as respects mankind, and especially the portion of mankind that want to be instructed, which includes the greater number at all times, and the whole at one time or other, the case is very different, and in the science of plants (for people will consider that the nonsense is part of the science as well as the sense) it is very much to be regretted, both as it discourages those who wish to learn, and as it embarrasses those who are already learned.

As there is, in very many cases, no reason why the plant should have the name that it bears rather than any other pronounceable combination of syllables or sounds; and as there is, in but too many cases, as little reason why it should be placed in one order rather than another, the whole nomenclature becomes a mere matter of authorities; and thus, in as far as that goes, the science, in respect of the classification—and that is a very essential part of it, the rest being individual or unconnected facts,—the science of plants is still much in the same state as all the sciences were when it was the practice not to believe in the truth but in the Stagyrite; and though authority may be all very good in those cases where nothing but authority can be got, to rest upon it is stopping short, even at the threshold, in every case where actual knowledge might be had.

There is another evil that arises out of the authority system; it holds out a temptation to false glory, and tempts even those who otherwise could and would do better to "call names," instead of investigating truth. How the mischief is to be avoided, it is not in the present state of our knowledge easy to say; but the fact is certain, that when a man of scientific habits examines a plant, and finds, not some property that does not *exist*, but some property which has not been *discovered*, in those plants that have been previously classed with the one in question, he is robbed of the glory, and the rest of the world are robbed of much of the utility, if he does not alter the classification and even the name; and unless the property be of so important a kind as to give a new use in the arts of life, the knowledge of it is confined within very narrow limits. Besides, the mere change of the classification, or the name, may be made without any discovery worth notice; and, as the doing of that is the popular part of the matter, there have been many wholesale bestowers of names that have never actually discovered so much as would warrant the changing of the most trivial epithet. All these changes are very perplexing; and when one that has yet to be initiated into all the contradictory and clashing nomenclatures is atttracted by the appearance of a plant, he must puzzle himself, perhaps ten times as long as it would require to know all that is known about it, before he can settle "under which king, Bezonian?" he is to admit its style and title. All that can with any thing like certainty be said in the present state of matters is, that the knowledge upon which a proper arrangement of plants may some time or other be founded, is making more progress than it probably did at any former period (and even that is not a matter of absolute demonstration); but when it will be as matured and perfect as the systems in the science of inorganic matter, to say nothing of the abstract sciences of number, magnitude, and quantity, there do not appear to be data for deciding.

Botanical classifications are of two descriptions—artificial and natural; but though the latter comprise, or should comprise, much more knowledge than the former, they are not absolutely different in kind. The foundation of the artificial system is, so far as it extends, just as natural as that of the other; and the very unsettled and changing state of the natural system proves that, if it be calculated to convey or embody more knowledge than the other, that knowledge cannot be obtained without some difficulty. The only artificial system of which it will be necessary to mention briefly the outlines is,

The Linnæan System.

The Linnæan system, so far as it extends, is remarkable for its clearness and simplicity. It is founded entirely upon the number and arrangement of the stamens and pistils; and were these found in all plants, and the number and arrangement in the same species always the same, the system, though it would not even then convey any information as to the nature of the plants (and of that the inventor was perfectly aware), yet it would form an easy and complete index to the knowledge of one plant from another, and that is at least a beginning. But a very large number of plants have no visible flowers at all; the majority of plants are in flower only at particular seasons; the number or the arrangement of the stamens and pistils varies in plants which are in every other respect the same; and plants may be different in every other respect and yet similar in the stamens and pistils, or they may differ in those and yet agree in many others of equal or greater importance as guides to the uses of the plant. One of the cases in which it is most desirable to have a short and simple system—a system that does not require a profound professional botanist, but may be part of the common education of all tolerably educated persons—is that of coming to new places in search of trees. A system of that kind would be very delightful; the man having it could never once stir on the earth's surface without acquiring knowledge, and a zest would be communicated to travelling, whether for short or long distances, or at home or abroad, which would fill up very delightfully, and far from unprofitably, those intervals of time which at home are spent in the ordinary relaxations of social life, and which at present either hang painfully upon the minds of those who travel or are wasted to worse purposes. But the Linnæan system is of little use in cases where there are not flowers, whether the secret arise from the fact that the plant is flowerless, or from the circumstance of not being seen in the flowering season; and thus the system fails altogether in the very cases in which it would be most valuable and certainly most desirable. The inventor is not to be blamed for that; for, imperfect though the system be in general application, it is beautiful for its simplicity, and where it can be applied it is applicable to very conspicuous, very attractive, and very essential parts of the plants. Linnæus saw the imperfections of it, even as applied to the plants that were known in his time, and in supplement he left his fragments of a natural system; and had he lived now he would, in all probability, have formed an artificial system with a somewhat wider range. It has of late been customary with some to decry and try to ridicule the Swedish botanist; but, if we may judge of them by their own achievements, if none but such as they had been alive at the time and since, we should yet have had no system equal to the artificial one of Linnæus.

It is true that the misapplication of that system has certainly tended to retard the progress of philosophical botany; but neither Linnæus nor any man else can, in fairness, be made responsible for the misapplication of his invention; inasmuch as there appears to be nothing exempted from misapplication by folly or by some other quality; and it would not be difficult, could one useful purpose be served by it, to point out very gross misapplications—

misapplications calculated to lead to errors of a much deeper character than any that have been produced by the misapplied system of Linnæus.

The radical fault of the Linnæan system is that, in the higher departments of the study of vegetables, it is of no value whatever,—that no conclusion, as to the general habits, cultivation, products, and uses of the plant, can be drawn from it. And that is very true; for the foundation of the system is not one of function, but of mere form, and of form which is not essential. Even in phenogamous plants, the mere fact that the seeds are fecundated and ripened is the only conclusion that can be drawn from enflorescence, and the difference in the form of the flower leads to no specific difference, even in the manner in which those operations are accomplished; and if the distinctions of the Linnæan classes and orders throw no light upon any differences in the maturing of the seeds, so as to be fit for germination, it would be contrary to all analogy to expect that they could take up the physiology of the young plant at an after period, and afford us any knowledge whatever of the mode of germination, or the form, habits, and qualities of the mature plant that springs from that process. The form of the stamens and pistils in the flower has no traceable connexion with any one quality of the parent-plant, even in those qualities upon which its external appearance depends; and, therefore, we cannot expect, in that form, any clue to the future plant. The qualities which, in their union, form, or rather characterize, that which we call a plant, are co-existent, and, therefore, the one could not, by possibility, originally suggest the existence of the other; because, before any one thing can lead originally to the knowledge of another, in any case, they must have been seen in a former case in the relation of cause and effect, and cause and effect is a relation of succession and not of co-existence. As the knowledge of the number and arrangement of the stamens and pistils does not reach to a single function, not even to the fertilization of the embryo seed, it is a *non sequitur*, and has no tale to tell but that of its own existence, like any other insulated appearance in nature. Granting that it were a link in the chain of causation (which is granting more than mere form will ever receive at our hands), it is a final link; and unless we can continue the succession unbroken, we must not attempt to reason; were that possible. Were mere priority in time sufficient ground for predicating the sequence of cause and effect, then any thing whatever might be made the cause of any other; and there would be an end of all reasoning and of all knowledge. All that we can conclude, when we find any mode of flowering on any plant, is, that the other qualities, which we observe in the same plant, may be expected in the young plant from the seed; and, as many of the external appearances, and those of the flowers among the rest, are produced, or varied at least, so as to appear much the same as new ones, by external causes, a person, not acquainted with the appearances of the plant in other circumstances, would predict the reappearance of those accidental characters in the seedling, just as readily as those that are less dependent upon circumstances. It is a well-known habit of some grasses that when they are in very dry situations they form bulbs at the root, while in situations that are more moist they do not; and if a person were familiar with one of those grasses in one of the states, and knew nothing of it in the other, what should prevent him, or how could he avoid, concluding that it would have that character on all soils and situations where it could be made to vegetate? One other consideration will more clearly show the fallacy of attempting to deduce one external appearance or form of a plant from another external appearance. The connexion that we fancy cannot be a succession of cause and effect, because it will go either end foremost; and, with the exception of *supply* and *demand* in political economy—which, though co-existents, are sometimes introduced as cause and effect, alternating with each other—there is probably no succession of causation that will admit of inversion. Indeed, if the inverting of it be not an immediate and palpable absurdity, we may always be certain that it is no instance of causation at all. Now we find, by experience, that the same flower is much more certain to come from the cutting or the bud of the same tree, than it is from the seed which was preceded by that flower itself. Thus, we must not find fault with the system of Linnæus, because it will not give us that information by inference which cannot, in the nature of things, be obtained but by direct observation.

The practical evil charged against the system is, at first sight, of a more serious character; for it seems to consist in degrading the name of science, by applying it to that which cannot be regarded as science at all. But the system was never intended to be in itself science, any more than the alphabet of language, the signs in algebra, or the marks for musical notes, are, in themselves, science; and yet, on those subjects, there was, probably, not much science before they were used. It has been much the same with this simple arrangement of plants. It has brought to the study of plants very many persons who would or could never have made their way through the intricacies of science; and it has made many patronize the science, and find those who had the capacity the means of exercising that capacity, who, but for the easiness of the system, and the eclât which even a knowledge of it gave them, would have remained in utter indifference to it. Hence, the vast numbers of new plants that have been discovered; hence improvements in the culture and products of the garden, the field, and the forest, which never before had any existence; and, hence, even the greater part of the materials that have been collected, and are collecting, out of which, if upon any thing, a good natural system may one day or other be formed. That the system conveys no information, but the fact of those appearances on which it is founded, is true; it is equally true that nothing can be philosophically, or even safely, deduced from it; and it is, moreover, true that a person may know the Linnæan characters of every plant in which they are found, and be able to quote the names of them all, and yet not be acquainted with a single useful property, or even a single trait of the general external appearance, of any one vegetable. Furthermore, it is true that there have been many persons who have rested at that, or even a great way short of that, and yet who have taken or had given to them the names of skilful botanists; and these they have had in hall and drawing-room, worn them fully and proudly to the limit of their mortal lives, and had the memorials thereof chiselled upon their monuments. But what of all that? In what science or in what department of human life is "the race to the swift, or the battle to the strong?" It rarely happens that those who are the most profound, and in the judgment of reason deserve it the most, stand highest in public estimation. Persons of that description have always, hitherto, been of the minority in the world, and a very great change must take place before they be found on the other side of the division.

It was, in truth, that very "nothingness" of the system, in a philosophical point of view, which made it so much a favourite with those who would have shunned it in any more formidable shape. The flower was cropped; out came the pocket magnifier, if necessary; the class and order were known at once; and it was only fetching home a little slip, and looking into the dictionary, to find the genus, the species, and the variety, and the whole botanical knowledge of an entire plant was gained. Then, if nobody had found it previously, in the same dell or dyke, in the same grove, or on the same common —O noble! it was a discovery!—and if no one had named it, it was the sum of mental delight. To give pleasure, is the ultimate object of all human study and exertion; and here was pleasure, abundant—almost universal—for something flowers at all seasons, and within the reach of all. And it must not be thought that there was no higher result. The beginnings of all things are small; there was a time when the most giant tree in the forest weighed not the ten-thousandth part of a grain; the greatest man that ever drew sword or wielded sceptre was once a mewling baby; and the philosophy of Newton was founded on A, B, C: and, but for their small beginnings, the lofty endings never would have been arrived at. To take pleasure in plants—in any thing that grows and lives—is a living and growing pleasure. What is loved, must be examined and thought of; and that examination and thought are the foundations of all science, how lofty and assuming soever. It may be all very well for those who are up to despise the ladder; but if they attempt to kick it down, that is only preventing the ascent of others; and there is little doubt that the abrogation of the Linnæan, or of some such artificial system, would greatly diminish the number of amateur botanists; who are, after all, in the fair road to the more recondite science of the subject, whether they may ever go the whole length or not; nor is there much doubt that if they can they will. We must be careful not to confound a simple system, which pretends to nothing but what it actually accomplishes, with a system of imposture which assumes that which it never attempts. Nature has so many pleasant ways of letting people into her secrets, that the grand point is gained when the attention of the *unlearned* is drawn toward her works.

And how stands it with the more lofty Natural Method? Is that all perfection? Far from it. Every classification must be artificial, inasmuch as nature makes only individuals, or at the widest species. Before, therefore, an order, a genus, or any other named or unnamed association of plants can be formed, all the characters of the individuals must be known. If they are identically the same, in all members of the divisions, then there is no classification at all; the whole are not only one species, but one variety. Then, if some characters are left out, it must always be matter of opinion whether these be less essential than those which are retained; and, therefore, that which is called a natural system differs not much from an artificial system, more complicated, and, therefore, more difficult to be understood. Every arrangement, the parts or sections of which are to contain even two species, must proceed upon *partial* resemblances between the one and the other; and in that case there is a limit, beyond which, for the purposes of the great majority of people, more is lost by the intricacy of the system—the number of parts, and the minuteness of the characters—than is gained. The real knowledge must, in all cases, be in that which can be actually examined and experimented upon; and that can neither be order nor even genus, no, nor species or variety—it must be individual. In the sciences of actual and tangible existence, generalization, however skilful it may be, is not knowledge; it is merely the arrangement of knowledge after it is obtained; and where there is an over-disposition to generalize, there is always some danger of neglecting those nicer shades of agreement and disagreement, upon which so much of the philosophy of the matter depends.

Of the structure of the Linnæan system, it must suffice to say that there are twenty-three classes founded; the first thirteen on the number of the stamens, the next seven on the arrangement or insertion of the stamens, and the remaining three on the positions of the stamens and pistils with regard to locality. The classes up to ten have their names from those of the corresponding numerals in Greek, with the termination *andria*, to imply that it is the number of stamens that is meant. The eleventh class is named from twelve stamens, but it includes those which have any number from twelve to nineteen inclusive. The twelfth class is named from twenty stamens; but it includes those that have a greater number, provided the stamens are inserted in the calyx, and not into the receptacle, the ovarium, or the petals of the corolla. It has been mentioned that the origin of all stamens is in the peduncle. The thirteenth class is named from many stamens, which have their insertion not in the calyx but the receptacle. The fourteenth order is named as having two powers, because there are two long stamens and two short ones: the two powers, which do not mean any other quality than their mere length, are the two long stamens; and, according to the same mode of expression, the fifteenth class, in which there are four long stamens and two short ones, is named as having four powers. The sixteenth order is called one brotherhood, the seventeenth two, and the eighteenth many, because the stamens are in those ways united together. The nineteenth class is called from the stamens having "a similar origin;" they are united in the filament; and the flowers are compound, or have many florets or little flowers on the same receptacle. The twentieth is named from the union of the stamens and pistils, which is the character of the class. The twenty-first is named as having one house, because the stamens and pistils are always on the same plant, but in different flowers. The twenty-second is named from two houses, because the stamens and pistils are in flowers on different trees; and the twenty-third class, which is rather confused and unsatisfactory, is named as having various unions, because the stamens and pistils are sometimes in the same flower, sometimes in different flowers upon the same plant, and sometimes in flowers on different plants. The greater part of the classes, especially those in which the stamens are numerous, are liable to anomalies; as the stamens are sometimes abortive or do not come to maturity, and at other times their places are occupied by additional petals in the corolla. It was formerly mentioned that certain diminished actions of the leafy structure of the plant are attended with an additional production of flowers and fruit; and it should seem that, by an intermediate culture, the stamens, sometimes in part, or even in their whole number, are converted into petals. Roses, which have only five petals, and have a great number of stamens in their natural state, are rendered double by culture; and a tree bearing double roses will often return to the producing of stamens when the culture is neglected. The dahlias, which are now so ornamental even in the gardens of cottagers, are remarkable instances of this effect of culture. It is needless to add that, when the stamens are obliterated, the seed-bearing faculty of the plant is at an end; but it is probable that, along with that, the tendency to grow by parting the roots, by slips, by buds, and other methods, is augmented. The twenty-fourth order contains all the cryptogamous plants, to which of course the system does not apply.

The orders in each of the first thirteen classes are founded on the number of pistils, as the classes themselves are on those of stamens; and it is a curious fact, though one from which no conclusion has been drawn, that there is hardly a flower with eleven stamens, or with nine or eleven pistils. The orders of the fourteenth and fifteenth classes, in each of which there are only two, are distinguished by the fruit; the sixteenth, seventeenth, and eighteenth by the number of stamens; and the nineteenth by various, and not always very satisfactory, characters. In the remaining classes of phenogamous plants, as the number of stamens is not a character of the class, it is made the character of the order.

As the principles of the artificial system do not apply to the cryptogamous plants, the orders into which he divided that class are natural, or founded upon the general economy and habits of the plants, as far as these were known to the author of the system. More minute examination of the structures of those plants, that has since been made, has occasioned a different, a more minute, and a more accurate division; and even the followers of Linnæus found it necessary to add one to his four orders. They were these: First, Ferns *(filices)*, which are the largest, at least of the land, cryptogamous plants. In warm countries, more especially in the southern hemisphere, some of them rise to such a height as to merit the name of trees. They have their fructification, or productive matter, whatever it may be called, generally in the leaves. The roots of many of them contain a considerable quantity of farinaceous matter, and serve some of the rude nations as substitutes for bread. Secondly, Mosses *(musci)*, which have separate leaves, and bear their productive matter often on stalks appropriated to that purpose. Thirdly, Liverworts *(hepaticæ)*, which have the leaf and stem united into what is called a *frond*, or expansion, and have their productive matter in little sacs *(thecæ)*, without any lid, or operculum to them, as is the case in the mosses. Fourthly, *Algæ*, including sea-weeds and lichen, which are without any parts to which the name of leaves can be given: they have their productive matter imbedded in the substance. Fifthly, *Fungi* (mushrooms), spongy substances of rapid growth, having their productive matter on various parts, but generally very minute; and probably passing through several stages of growth before they become visible. Small roundish vessels in them are sometimes called seeds; but as these are filled with grains of powder, almost, if not altogether impalpable, they are in all probability vessels, each containing a vast number of grains. Such is an outline of the Linnæan system; and the details are so easy that they may be learned by once reading any of the common elementary books.

There were some anomalies in that system from the beginning; and as a more careful examination of the vegetable tribes, more especially those of the equatorial and southern parts of the globe, was extended and became more accurate, the anomalies increased in number, till in some of the orders the exceptions to the rule became more numerous than the accordances with it; and thus some change became necessary for the sake of consistency. Whether the Linnæan system could have been so remodelled as to get rid of these anomalies, and still arrange the plants according to the form of the essential parts of the flower, or whether the whole reproductive process could have been so much cleared up as to include the cryptogamous plants with some more precision than belongs to the five vague orders that have been named, it is of little consequence to inquire. The fact is, that it has not been done; and thus the natural system became necessary, and for scientific purposes is certainly superior to the former, as it leads more directly to the general properties, the habits, and the uses of plants. We shall notice one or two of the characters on which it is founded.

The Natural System.

In order duly to appreciate the merits of what is considered to be the natural system in the arrangement of vegetables, it is necessary to consider what ought to be called a NATURAL ORDER. There is no relationship between one plant and another, farther than similarity of structure and habits; and therefore that order will be the nearest approximation to a perfectly natural one, in which there is a near coincidence between the greatest number of characters and habits; and if the approximation is even tolerably close in a number of particulars, the order will be much more natural than if the coincidence were only in one particular, how perfect soever it might be in that.

If we are to arrive at the same extent and accuracy in our knowledge of plants, we must not imagine that, with all its simplicity, the Linnæan system will forward us a jot more than the other. The want of a "royal road," which was long ago declared of geometry, is equally true of every science; and as long as people continue to be born without any knowledge, so long must the acquiring of the same extent and accuracy be the result of the same labour. It is true that the knowledge which we derive from books and instructors puts us sooner in the way, and saves us the long and painful investigations that are inseparable from original discoveries; but in proportion as these shorten the process in the individual instances, they increase the number of these, so that, in proportion as any one generation finds more done, and easier modes of doing it, the individuals of that generation find more to do. On that account, though it may be much easier now for any one to attain as much knowledge of plants as existed in the days of Linnæus than it was then, it by no means follows that less talent, less time, or less labour are now necessary, in order to make a man comparatively as good a botanist as he was then. There are many persons yet living, and in the full possession of their faculties, who were accounted very good botanists in their day, but who now, from having stood still while the science has been advancing, are very tyros compared with those who are much their juniors in years and their inferiors in talent.

The difference between the system,—between any system which is artificial, whose principle is an alphabet, and the volume embodying which is a mere vocabulary,—and a natural system, founded on the knowledge of the subjects which it professes to systematize, is simply this:—that, in the artificial system, the difficulty, the real knowledge, that which alone requires thought and study, does not come till the genera, the species, or perhaps even the individuals, are arrived at; while, in a natural system, the "tug of war" is at the very threshold; and, when that is once crossed, all is ease and pleasure. And who that has seen the ardent mind of youth writhing and struggling under the load of unremoved difficulty, which the curse of "easy introductions," and yet more easy tutors, has heaped upon it in one case, but must exult that, for the benefit of those who *do* wish to be instructed in knowledge, a system in which there is no such load upon the mind—a load under which nine-tenths of the students of almost every subject that requires thought are most cruelly broken down, and "done to dulness" for life—has been introduced into the delightful science of plants—the most delightful and the most useful of all sciences. 'Tis well that the artificial system should remain, for the sake of those that neither can nor will understand the other, because they may give that eclât and that aid to a science the extension of which is expensive, which men of greater mental grasp and penetration have seldom either the means or the leisure for giving; but still one cannot be too thankful that those who have the capacity of doing better should also have the facilities. And, in consequence of the great and general good which the promoters of that more rational system pursue, we ought to be gentle to any little slips and errors which they may make in the pursuit. Where labour is severe and long, the labourers must sleep sometimes; and it is in accordance with the general law of nature that those who have the most active minds, have the wildest vagaries in their hours of slumber.

The grand advantage of the natural system is that it regards any plant as one organized and symmetrical being, having the law, or the habit, or whatever else it may be called, which makes it that plant and not another one, stamped upon its whole organization, throughout its whole existence. All the parts of that organization may be much varied in their natural appearances—their shape, their colour, their number, their consistency, and their duration. All the evolved parts are the results of *stimulation*; the stimuli are all from without—were it not for a certain degree of temperature and humidity, the seed would not germinate at the first, and the plant would slumber in an endless winter, till the action of physical causes reduced it to dust, if it were not for the shower and the sunbeam of the spring; and, therefore, the result of the stimulation, be it what it may, must depend partly on the stimuli as well as on that which is stimulated. We have a striking proof of that in the mode in which varieties of flowers are produced from the application of the pollen of one plant to the stigma of another. The resulting flower—that is, the flower obtained from the seeds—always partakes of the qualities of both; and those who are in the habit of performing the operation frequently, and know the effect of situation and culture upon their plants, can tell very nearly what will be the appearance of the hybrids.

This same illustration proves that there is, in the thing stimulated, an identity which it will not relinquish, and which cannot be altered beyond certain limits; and it is of course the same with the stimuli of different earths and atmospheres, as with those of different pollens. Thus, while the scientific botanist allows for all the variations that may be produced, he has still an unchangeable identity in his plant, by which, if his information be of the proper kind and degree, he can be certain of it amid all its changes. This unchangeable identity is *the natural character* of the plant, as a *species;* and could it be analyzed into all the perceptible parts of which it is the generalization, and each of these perfectly and clearly expressed in words, the science of botany would be rendered as plain and demonstrative as the science of geometry. In geometry, there is no *universal à parte rei,* any more than there is in botany. Orders and species are formed by analyses, in the one science just as much as in the other; and if the analysis, in the case of plants, could be rendered as plain and perfect as it is in the case of magnitudes, the science of the one would be founded as much upon demonstration as the other. What is that which we call a solid, but a figured magnitude having three dimensions, each one posited at right angles to the other two; and that is one *order* in geometry. Analyze away one of the dimensions, leaving the other two?—and there is a second order—a *surface:* analyze away another, and there is a third *order,* a *line.* Then of any of these orders there are many species, all of which are distinguishable by a further analysis of the parts or properties that constitute the order, though they do not of necessity enter into the definition of it. Thus sides and angles are not made part of the character of the *order* surfaces, because some surfaces, as the circle, have neither side nor angle; but they belong to some of the species—as for example, surfaces having three sides and three angles, form, or belong to the species, *triangle;* and the mere fact of having these is the *specific character,* by which triangles are distinguished from all other surfaces. But, in any particular triangle, the angles must have some proportion in magnitude, and so must the sides; and neither of these can form part of the specific character. It is a property of triangles, that, when the angles of one are all respectively equal to the angles of the other, the two figures are of the same shape, or, as it is technically called, similar. Any number of triangles that have their angles equal, will thus form a *variety* of triangles, having one character more in their definition than is alluded to in the description or definition of the species. If the third character be added, the sides all respectively equal, the triangles will be *identical* or the same in every respect. And why the same? Simply, because, in all the properties that we can imagine to belong to triangles, we are unable to find any difference between the one and the other.

That which has been stated is a perfectly natural system of geometry; and were we to consider triangles on curved surfaces, as well as those on plane or flat ones, we should have the general word triangle, as the name of a *genus,* and of a genus, in its full extent, as perplexing and as full of indeterminate points as any genus in botany, or in any thing else; and the plane triangle would be a simple, or well, or easily understood *species* of that most puzzling genus. Nor would the genus triangle, thus taken, as including all triangles whatsoever, be the only puzzling one; for in the three orders of solids, surfaces, and lines, there would be puzzles enough in all the genera; and, simple as it may seem, it is just as impossible perfectly to express a circle in terms of a straight line, as it is to express a fir-tree in terms of a sycamore. Now, if there be this difficulty in the system of that science, which, by common consent, is held to be the most clear and satisfactory of all—and those who are not aware of, and have not felt, and fought with, and *never overcome* the difficulties, are at least as *artificial* in the *science* of figure and magnitude, as the merest *nominalist* in the Linnæan system is in the *science* of plants—how much more may difficulty be expected, in a science which embraces so many more of varied elements, and so many of them complex and baffling to the nicest analysis? In the most perplexing problem of geometry—even in a *transcendental* problem, from which geometry turns away in despair, there is nothing but figure and magnitude; and these never change in the same figure. But the problem, which the botanist is called upon to solve, in the case of even one of his (say) twenty thousand species, and their millions of millions of varieties, is the "story of a life," with all its stages, its accidents, and its results. When the proper view of the matter is taken, the wonder (with those who do not feel what is to be done) should be, not that there is so much to be done, but that so much has been achieved.

Those who understand any thing about science (of any kind) will not, however, wonder the one way or the other. They know that demonstration, how much soever those who have been working in a corner may boast of it in that corner, rests on an exceedingly simple foundation, and one for which no man can claim any merit—the intuitive or irresistible belief that any two subjects of perception or thought are the same, when we can feel no difference between them. This belief is as irresistible on one subject as on another; all that is required of us is to *know* that we believe, and not merely *say* it, and then all our systems will be natural.

To form a natural system of plants, we must begin at the beginning, for plants are a part of the more general system of nature; and, in selecting the character of the kingdom, as we may call it, we most include every thing that distinguishes plants from existences that are not plants, and exclude, as carefully, every thing that can, in any way, distinguish one plant from another. In that way we define the limits of the kingdom of which we are to acquire the science or knowledge.

In the formation of our great divisions or *classes*, which should, if possible, be so distinct and obvious that the most ignorant person may at once see them, we must fix upon that character for each class which distinguishes all the individuals in that class from those of every other class, but which does not, in any way, distinguish one individual of the class from another; but the more we can ground our classes upon the *natural character*, and avoid those characteristics of the individuals that are liable to be changed by circumstances, the better.

When we subdivide again—as when we separate our classes into *orders*, we have merely to take a greater or a smaller portion of the class that resemble each other in some other of their characteristics or properties, than those on which the class was formed, carefully excluding, from the definition or character of the order, every circumstance that tends, in any way, to distinguish one member of the order from another.

As orders and genera are the intermediate parts of the system, between classes, in which the points of resemblance are necessarily few, and species, in which they should be as numerous as possible, it becomes a question whether the actual knowledge of plants should be chiefly applied to the formation of orders or to that of genera. In the artificial system the greater part of the characters were left to the genera, except those unimportant ones upon which the previous part of the system was founded; and, feeling the disadvantage of that, there has been a tendency on the part of those who have learned or altered the natural system, to fall into the opposite extreme, and exhaust the greatest part of the knowledge of plants, in the formation of the orders. In consequence of that, the whole number of orders has been increased to nearly three hundred; more are adding from time to time, and some of those orders do not contain more than one genus, or even one species. There is no doubt that this minute division into orders makes the knowledge of the species more easy, just as the orders were easy in the artificial system; but the proper point at issue is not whether orders or genera shall be the more easy to be understood, but how, by the learning of the two, the whole knowledge of plants can be most easily acquired, and most conveniently used and extended; and really, upon the principle of analysis —the principle upon which the whole acquisition and use of the knowledge must proceed—it seems that, as both the orders and genera are mere steps to lead us more easily from the class to the species than if we had to take the whole at one leap, it does appear that the more equally the labour is divided between the two divisions, the better. In the natural system there are only, strictly speaking, two classes, plants that have visible flowers, and plants that have not; and the transition from these two to nearly three hundred orders—the transition from the first one to upwards of two hundred and seventy orders, is much greater than that from any one of the orders to the genera that are included in that order. The only use of steps or ladders, whether physical or intellectual, is to make the descent easy, and that is always the better effected, the more equal that the steps are. It may be thought that the eminent persons, by whom the system is formed, are, if not the only judges, at least the best judges of the matter; and, in as far as the truth of any thing stated is concerned, that is without doubt the case. But the mere arrangement is a matter of convenience, and not of truth or falsehood; and the proper judges of it are those for whose convenience it ought to be made, that is, they who have yet to learn. Of the difficulties that they may feel in the system, the framers of that system cannot be judges, inasmuch as they must have made the system from previous knowledge of what it was to include, otherwise it is not a natural system founded upon natural characters, or even an artificial system founded on one character, it is an ideal system—a mere hypothesis. There is no doubt that it is owing to the number of orders in the natural system that it is so unsettled; and as little doubt that the number and the changes together have no tendency to make it attractive to people generally.

In forming genera, we subdivide a second time; and take characters that belong only to a part of the order, make them the generic character, and in the formation of that character, carefully excluding every characteristic by which one number of the genus is distinguished from another.

When we have arrived at the genus, we may understand that the points of resemblance, among all its members, are more numerous than the points of difference, though the degree in which the one exceeds the other must vary, with the actual qualities of the plants, and also with the extent to which those qualities are known. And, when we come to the species, the characters which we have selected, as being the natural ones, should be common to the whole; for if the members of the species have not exactly the same natural character, the collection of them is not a species but a genus, or an order under a different name. A *species* is that which is fully seen or perceived; and, therefore, whatever is the character upon which we proceed in our classification, the whole of it must belong to the species; and lower or more minute than that there can be no natural division. It is true that we have *sub-species* in several parts of the natural sciences; but these are all imperfections, or rather inaccuracies. They arise from new discoveries, which the specific characters, taken of course only from what was known at the time of their formation, will not embrace; but the fault is in the system, and where there are sub-species, the species itself is a genus or a sub-genus; substitutes or subs, are bad, or at all events awkward, in scientific arrangements; but if there must be a sub, by all means let it be a sub-genus, because, with the genus, the character, upon which the classification is founded, is not exhausted; but with the species it is; and thus the sub-species, coming after the species, is like the book-maker of the olden time, who, first having treated *de omnibus rebus*, found it necessary to add a few volumes *de quibusdam aliis*.

After the species there are indeed *varieties;* but varieties are changes, and not original differences, so that they can be distinguished from each other by no part of the *natural character*. Did that, or the smallest part of it, distinguish them, they would be species and not varieties. The causes of the variety must be wholly external of the nature of the plant as a species; and thus they must be wholly the result of external circumstances.

Such are the parts and the mode of arrangement in a natural system, from the plant having only one general trait of natural character, to the species, which must have every trait of that character. The intermediate divisions are, of course, arbitrary. They may be fewer or more, because no reason can be assigned why they should be one number rather than another,—all that is essential being that the whole natural character should be exhausted in the species; and upon what intermediate ranks it is pointed out, is a matter of taste and convenience. In those cases the medium is safest; and change should be avoided as much as possible. The reason of that is that the books which are already in the hands of the public cannot be called in and changed with the changes of the system, and that, consequently, every change renders them less useful, and the whole science more embarrassing and hard to be understood: thus the triumph of a bold system-maker is sometimes won by the prevention of as many students, as that of a gallant warrior is by the destruction of human beings.

What has been mentioned of the system is easy; and if it were as easy to frame a natural character which would satisfy (that is, perfectly discriminate) the species when we come to them, the science of botany would be as complete and easy in practice, as it is beautiful in theory. But we must go in search of that, and, before we can tell from what parts or appearances of plants we are to take it, and what we must reject, a perfect knowledge of the whole of their structure, habits, and economy, would be necessary. That may probably never be attained, because, as has been hinted again and again, there are operations of these organs, and states of them as wholes, in which they cannot be made apparent to any one of our senses, and of course we cannot have any knowledge of them in those states. Of what fraction of the whole that which is known may form, we are just as ignorant—it may be the half, the tenth, or probably not more than the ten millionth, or not so much; but it is all that we have; and we must frame our natural character out of that: for if we add one iota of conjecture, the truth and value of the whole are instantly destroyed.

To form the natural character of the species, we must get at all the known characteristics of the plant, which do not admit of change by changes of external circumstances; and we must exclude all appearances that are not original in the plant, but changes by action from without, different from that action of the common stimuli which is necessary to the ordinary healthy functions of any plant of the same species. As our knowledge, taken as a whole, is only an approximation, the several parts of it can only be approximations too; and thus, though the character must be more definite in proportion as the plant is better known, no character which we can form can be absolute. There is this advantage in the natural system, however, that when we go about to acquire knowledge from the simple character of the class to the compound character of the species, we take science with us at every step —the inward structure, and the functions of that structure, as well as the external appearance. Thus we have a guide, not indeed a perfect guide, but one approaching as nearly to it as the nature of the subject will allow. If we find that a certain difference of appearance is accompanied with certain corresponding differences of structure and functions, we may conclude that that is part of the natural character of the plant; if not, our conclusion may be of course the reverse: that property belongs to every part of the character, whether it is to be made distinctive of class, order, genus, or species; and thus, branch out and distribute them as we may, the characters must be all chosen upon the same principle. At the same time it is not necessary to name all the branches of the character. We may content ourselves with that which is the most obvious, and may be procured at once in the living plant, without any dissection or experiment, because that is the one that will be most generally understood.

The characters of *phenogamous* and *cryptogamous*, which are used as descriptive of the two great classes of plants, are perfectly natural, and they have the popular quality of being easily seen and understood. They are combined with other characters in the whole structure and functions of the class. All the flowering plants (at least the exceptions in plants that actually have *flowers* are few, if any) have spiral vessels; and they all have cotyledons, or lobes, or something that answers that purpose, and also an allocated germen, more or less developed, in the seeds; while the plants, on which flowers are not perceptible, but which form productive sprouts, or whatever they may be called, in their substance or on their surface, without any flowers preceding the formation, have none of these characters. These last are all, therefore, *acotyledonous* and *cellular*, as well as *cryptogamous*; in like manner as the former are *cotyledonous* and *vascular*; but the flowering and not flowering, are the more obvious characters; and, therefore, the preferable ones from which to name the classes.

The modes of growth in the two sub-classes of phenogamous plants, *endogenous*, or growing at the centre, and *exogenous*, or growing at the outside, are natural characters. The former plants have the pith, wood, and bark, or at any rate the cellular and vascular structures, of which all these parts of plants are made up, all blended together, while the latter have them distinct, and the wood and bark performing different functions. All the *endogenous* plants also have but one cotyledon, or lobe in the seeds, while the others have two or more. But those accompanying characters, though as constant as the others, are not so easily seen, and therefore they are not so fit for giving the names to the sub-classes. Sub-classes, it may be remarked, are, in the case under consideration, perfectly unexceptionable; inasmuch as the divisions founded upon them are too few and include too many plants for being admitted as orders, though they are too marked and too expressive of the general habits of plants, for being altogether overlooked.

There are, even in a few genera of each of these sub-classes, certain approximations to the habits of the other, although so weak as not to warrant a removal from the one class to the other. The endogenous grasses have, in the early stages of their growth, a semblance at least of wood and pith, the vessels being ranged around the outside of the stem immediately under the epidermis; and soft cellular matter, analogous to pith in the centre. That pith is generally, however, only a deposit of matter, for the further elongation of the stem, and the production of the scape or flower-stalk with its spike or panicle of flowers; and thus, when the plant comes to maturity, and even before the seeds are refined, the stem becomes hollow, by the application of the cellular matter to that purpose; and, generally speaking, the hollow occurs first in the lower joints of the stem. Many of the rushes *(junceæ)* have the pith more divided and permanent, as in the common rush, the pith of which is used for the wicks of lamps and small candles; but in many species of the same genus, the pith has much less consistency, and in some it is altogether wanting, except in the very young stages of growth.

In some of the exogenous plants, there are, in like manner, approximations to the structure of the *endogenæ*, but without any departure from the increase at the surface, which is the character of the sub-order. The plants which have this resemblance to both divisions (chiefly the *coniferæ* and the *cycadeæ*, or sage palms) serve to point the way to some characters that may be depended on as truly natural, and also to guard us against attaching importance to mere number, in any organs of plants.

These plants have the fibres or vessels in the wood straight, and with comparatively little lateral cohesion; they have the vessels in the leaves also straight; and those which have these characters the most decided, do not form buds except at the nodes or joints of the stems, and many of them never form any second buds even then. Thus a correspondence is established between the structure of the wood, the woody part of the leaves, and the manner of budding, which is part of the proper economy of the plant, and does not, in any way, depend on external circumstances. On the other hand, the same plants show that there is not much more connexion between the cotyledons of the seeds and the general economy of the plant, than there is between either, and the number of stamens and pistils. If being monocotyledonous were the essential character of the endogenæ, then the greater the number of cotyledons, the farther would the plant be from that character; but some of the coniferæ, and even those of them that approach nearest to the grasses in their wood and leaves, have twelve cotyledons or more; while many plants of the very opposite character have only two. The pines, too, though they have the *ovulum*, or rudimental seed and the pollen, the essential parts of flowers, have nothing which can properly be called calyx or corolla, or even pistil, or anther; nay, not properly an ovary, except that name is to be given to the outer tunic of the seeds,—there being no carpal envelope whatever; and the plants being thence styled *gymnospermous*, or naked-seeded. In the Linnæan system, the cycadeæ are arranged as having many stamens, and cycas as having one pistil; but though these characters are not very clear (the fructification bearing a great resemblance to that of the *diœcous* coniferæ,) it shows that the number of any parts that may be connected with the fructification, cannot be the foundation of any very general character.

After these classes, and the sub-classes or tribes into which they are separated by very general and well-defined characters, there is no longer a perfectly natural nomenclature. The basis of the orders and genera are certain specific characters of certain plants, which are applied to other plants in which they are found, in accordance with other characters; and thus, unless where there is one very obvious and decided character in which they agree, the name of the plant upon which it is founded, which ought evidently to be the best known and the most easily accessible plant belonging to it, should give the name to the order or the genus. It is here that the disadvantage of the unscientific and vicious nomenclature is so much felt; but there is little chance that it will ever be remedied. It were to be wished that those persons who are ambitious of a vegetable monument, would select some one growing tree,—and, in general, they would have no great difficulty in finding one that would outlive all other memorials of them; then they would leave the renewable plants free to have names which would be some sort of indices to their qualities, or to their leading ones. In that case, the very name would give some knowledge; and every one feels how very *natural* that is, how very easily understood those orders are which have natural or descriptive names. How simple and easily known *graminæ* is to any one who knows that *gramen* means "grass;" how simple *coniferæ* to any one who has seen the seed vessel of any kind of fir; or *umbelliferæ* to any one who has seen a carrot or a carraway in flower; or *cruciferæ*, even to the most unbotanical farmer, as he objurgates the golden glories of wild mustard in his fields. Nay, there are few persons who have not heard as much of the fabled many forms of *Proteus*, as would lead them to expect something like that rich variety which is found in the beautiful and curious order, *Proteaceæ*. But really, when we have to deal with *Malesherbiaceæ*, *Niebuhria*, *Fouquieraceæ*, and very many others, after we have had our jaws nearly broken by the shell of the word, we have not even a worm to console us for the danger. Not one of the order, which is so named, can have one single quality in common with that to which, without the knowledge to which the name ought to be an index, every body must apply it; and thus, such names are, really, of no more use than no names at all. There is this plea in behalf of the imposers of nonsense names, however, that they must have something to call the plant by, before they have found out its qualities. Even those names are better than nothing, for they excite curiosity, and that is an antecedent, though not the immediate antecedent, of knowledge; and these are reported to be in certain quarters many, some plants which are not even publicly known by name, in as much as the ceremony of nomenization has not been performed on them.

Sources of Specific Characters.

What parts of plants should be chosen and what excluded, in the formation of specific characters, or in the grouping of species into genera, and genera into orders, is not absolute, but depends on the state of our knowledge as derived from observation. The maxims are short as well as important, and every one should have them in mind at all times, so that they will bear to be repeated. "The less that any property of a plant is changed by changes in the treatment of that plant, the better is that quality adapted for being part of the specific character; and no property that can be obliterated, or wholly changed by any difference of treatment, ought to form a part of the specific character at all. In like manner, those parts of the specific character that vary the least, and are the most easily seen, and thus the least liable to be overlooked or mistaken, ought to be selected for the more numerous groups." In applying those maxims to some of the parts of plants, we must be guided by what has been done; because, whether that be exactly what ought to be done or not, cannot be settled in the present state of our knowledge. We shall begin with the roots.

The roots of plants appear to be very much under the control of circumstances, and, therefore, no very certain character can be founded upon them. Some entire orders of plants have thick, fleshy, or farinaceous roots,—as the gingers and arrow-roots, among phenogamous plants, and the ferns among cryptogamous; and in some bulbs are usual either whole or divided like the former; but those forms are found only among endogenous tribes, and they are not strictly characteristic of the orders as these have been formed. Many of the exogenous plants form bulbs or tubers, but these are not general in the orders, or constant in the species. The most common of the *cruciferæ* have no bulbs as the turnip has, nor have the most common of the *solaneæ* any tubers like the potatoe; and even in these, the quantity and quality of the bulb or the tuber depend very much upon culture. Perhaps it is as well that much of the character does not depend on the root; because, in that case, we should have to pull up, and, by that means, very often destroy, every plant that we examined.

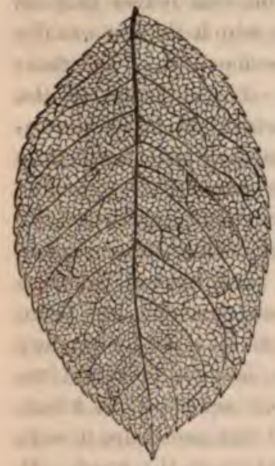
The stem, or trunk, is of more importance. There is a character in the bark, especially of perennial phenogamous stems,—as might be expected from the bark being one of the working tissues in the vegetation of the plant. There is even an external character in the bark, by which species can be distinguished; but the varieties are so many that no general description of it can be given. In the wood of the stems, too, there is a decided character, which always has some correspondence with the mode in which the vessels ramify in the leaves; but that also does not admit of general description.

In the pith there is little character, further than that where it is most abundant, the tree is, generally speaking, of rapid growth. In the external form of the section of the trunk, there is not very much character. Some trees that form heads of branches, of nearly equal height, as the yew, often have the trunk with a clustered appearance, by the formation of projections, like those of a reeded column, under the branches. These are most conspicuous after the trees have become hollow, though, even then, they are not general. On the mountains of Morven, between Laudle and Kin-Loch-Alin, there used to be (and perhaps is still) a curious old hawthorn, a considerable part of the trunk of which, toward the ground, consisted of dozens of little stems ranged round the hollow. Some part of these was, no doubt, roots that had been bared by the wasting away of the soil; but a considerable portion had once been a solid trunk, and in some places the dead wood had been exfoliated, and the bark was nearly closed over the wound. The vegetable history of that district is worth studying. There are now few trees living in the interior; and it is drenched with the salt dew of the Atlantic, while the winds, produced by the currents of Loch Linnhè, the Sound of Mull and Loch Sunart, on three sides, war continually upon it. Yet there are trunks of absolutely giant dimensions lying mouldering among the mountains; and, at one place, in the pass, leading from Ardgower, there is (or once was) the remaining outside of a root, that served as a little fold for cow-milking. On the coasts there are still highly productive coppices, and at Acharn there used to be some of the finest lime-trees in the island — *verb. sap.* — No — to the proprietors. — From the forms of herbaceous stems some characters are obtained. In the mints *(labiateæ)* they are always square; and in the *stellateæ*, or those plants that have the leaves set round the joints of the stem like the rays of a star, they are always angular; but in the greater number of herbaceous plants, no connection has been traced between the form of the stem and any other character.

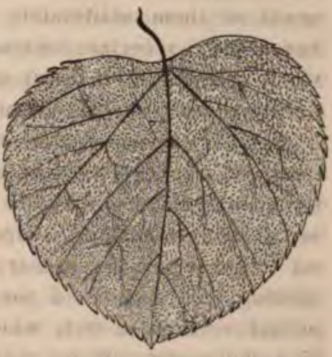
In stems of very long duration, such as those of trees, there is more deviation from what may be considered the natural habit, than in those that are shorter lived. Thus the form of the bole of an old tree is a tale of time—a register of seasons and ages, rather than any declaration of a species of tree; and, if carefully studied, the information that may be obtained, from such trees, is of considerable value.

From the activity of leaves, and the great importance of the functions which they perform, it is natural to suppose that they would be very useful indices to the characters of plants; but they are, from their very activity and exposure to all changes of circumstances, necessarily much modified by these. There is a general character in the leaf, by which any one, who is intimately acquainted with plants, can at once tell to what plant it belongs, even though it be not of the usual form, or though the form of it has been artificially altered; but that, like all characters drawn from the general appearance of individuals, cannot be expressed in any shorter way than by a particular description for each plant. The position of the leaves, with regard to each other, is used, but it is not absolutely depended on,—as leaves may be produced on parts of plants which do not usually produce them, or they may be abortive, or the rudiments of them obliterated. The divisions of the leaves are no certain character; as many plants, which are unlike in most other particulars, have leaves divided into the same number of segments, arranged in the same manner. Thus pinnated, or feathered leaves, consisting of leafets on each side of the midrib, generally are accompanied by papilionaceous, or butterfly-shaped flowers; but there are exceptions, as the true acacias and many others. The texture of the leaf is of more importance. Firm leaves, which are those in which the vascular structure prevails the most, are always accompanied by a similar texture in the wood. If the ramifications of the riblets are of very unequal sizes, the wood has usually a varied grain; and if the ramifications be more uniform and very fine, the grain is uniform. The lime and the sycamore are remarkable for the beauty of their vascular structure, which any one can easily examine, by macerating the ripe leaf long enough for removing the cellular matter, and then leaving the vascular net, or lace-work, to dry; and the wood of those trees, especially the lime, is remarkable for the uniformity of its grain, and its admitting of being cut in any direction with little danger of splitting.

Ash has qualities the opposite of lime: it is very tough, but easily split; and the difference in the vascular structure of the leaves is striking, as may be seen in the following figures.



Ash.



Limetree.

The way in which the riblets diverge from the midrib, the order in which they are connected, and the directions of the principal ones, are all characters of particular genera; and so is the presence or the absence of those pellucid dots, or follicles, which are understood to secrete and give out volatile oils, on which the particular odours of plants, apart from those of the flowers, are supposed to be chiefly dependant, are so many characters of those orders or genera in which they are found; but, like many of the other external characters, they are so varied, in the different plants, that they form part of the minute descriptions.

Stipulæ and bracteæ, at the bases of leaves and of flowers, are inactive things, and, therefore, little character can be expected from them; though they, too, are useful in discriminating individuals. The same may be said of thorns and prickles; and these are all very much modified by external circumstances, and belong more to the accidental or trivial character of the species in which they are found, than to the natural and permanent character.

There are many characters that depend upon the form and structure of flowers, but they are not of the most decidedly valuable kind, as many of them are liable to variations. When, however, the general character of the flower is so conspicuous and striking as to preserve a general identity amid the partial variations, it is more important, and may give the name. Thus, for instance, plants with composite flowers (*compositæ*), that is, those with a number of florets upon one continuous receptacle, form a very natural order; and the variations from the usual structure are never so great as to cause much hesitation as to whether any particular plant belongs to that order or not. This is a case, too, in which one definite general character, belonging to the inflorescence of a great number of plants, admits of subdivisions into other characters, nearly as definite as its own; while its own character remains certain, in all the sections. The three sections of compound flowers are *cichoraceæ*, *cinarocephalæ* and *corymbiferæ*. The first have the flower resembling succory or endive; the second have heads liket he artichoke; and the third have small compound flowers upon a branched peduncle, but not all dividing at one point, as in umbels, and forming a corymbus or bunch. Each division has considerable uniformity in all its qualities. When a subdivision of this kind can be established, with the leading character of the order conspicuous in all the divisions, and with an equally distinct character for each of these; and also with both characters accompanied with other common characters, independently of those by which the more minute division of genera and species is discriminated, it renders the knowledge of such an order, especially if it combine many species, much more simple, as well as much more satisfactory.

As the calyx and corolla are not absolutely essential parts of a flower, and as their functions, when they are present, are not determined, no character which is perfectly natural, or which forms part of the economy of the plant, can be deduced from their absence or their presence, or their form or composition, when present. When, however, a particular structure of calyx, of corolla, or of both, is found constantly, or generally, to accompany certain other peculiarities of structure or habits in the plants, then it becomes a distinguishing character; and, in the absence of others, it sometimes is found necessary to regard it as an essential one. It has the advantage of being easily observed when plants are in flower, as belonging to a part of them that attracts general notice; and thus, though we are not able to say "for what" other than mere appearance plants are distinguished, it does serve as a means of knowing one plant from another.

The characters that are obtained from the calyx and corolla, and also those that are obtained from the insertion and adhesion of the stamens, are not natural characters, any more than those that are founded on the numbers of stamens, their various lengths, and their formations into fasciculi or tubes. The use of the pollen and the germen are known; and, from what has been said of the coniferæ and other plants, that have the seeds without any carpal envelope, it appears that the absence of an ovary has some connection with the whole structure and action of the plant; but nothing is known of such a difference dependant on the length or shortness of the stamens, or their insertions above or below the ovary, any more than is known of the use of their number, or of the number of stigmata, or their form. Distinguishing characters, be they what they may, are never unworthy of notice; and when the use of that particular position, structure, or number of parts, upon which they are founded, once comes to be known—if ever it shall so come—they will become natural characters; but, till then, they are no more natural than the foundations of the Linnæan classes and orders; and, in as far as the system is dependant upon them, in so far it is artificial, and not natural. It may so happen that many of the orders, that they help to distinguish, are natural; and it so happened that some of the

Linnæan classes, as, for instance, *icosandria* and *didynamia*, were also very natural; but as the circumstance of the Linnæan classes being natural was not a consequence of those classes having "twenty stamens, or more, inserted into the calyx," as in the one class, or "two long stamens and two short ones," as in the other class, but another co-existing character, so also must the fact of being natural not be a consequence of the stamens being united to the ovary or separate from it, but of those other co-existing characters, by means of which it is found out that the orders are natural. It cannot be too often repeated, for it has been much and often lost sight of, that there cannot be two co-existent characters or qualities, and one of them the cause of the other. That the stamens are inserted in one part of the flower and not another, affords no more information than that they are one number or shape rather than another, or than that they are in the same organization with the pistil, or in a different one, or on a different tree, and that information is simply the fact of their own existence in the place where they are found. If we could deduce one fact from another, without any previous experience of their sequence, the acquisition of any kind of knowledge, by any sort of means, would be an easy matter, and we need not despair of at once finding out all the appearances and properties of an unknown flower, by simply smelling at it in the dark.

The characters that are derived from the number, form, and dispositions of the cotyledons, and all the parts of the seeds and seed-vessels, are of a similar description, being of no farther value than as mere marks of distinction, unless we find them invariably accompanied by other characters; and, indeed, if we are to rest our knowledge upon any single appearance of a plant, be that appearance what it may, our knowledge has not, philosophically speaking, much more value than if it had been confined to that of "the plant with the greenest leaves," or even that of "the plant next the wall."

Those, therefore, that describe the Natural System as vague and unsettled, because of the disputes and disagreements in opinion among its professors, do it great injustice. As a *natural* system, it can have no uncertainty, and admit of no rational dispute; for every natural character is a fact, and so there can be no disputation; the dispute and difference of opinion arise from uncertainty, whether the character at issue so harmonizes with established facts as to be a natural character or not. As long as men, who are competent judges of the matter at issue, and free from prejudice respecting it—and the opinions of any others are not worth noticing—continue to dispute, so long is that matter part of an artificial system, by what name soever it may be called, and whatever it may become after more knowledge respecting it has been obtained. And that disputation, properly conducted, so far from being blameable, is at once the surest proof that the parties are anxious to get the truth, and the clearest evidence that they are in the way of it. Passive obedience never was a sign of understanding; and the battle which mankind always fight before they receive the truth, has hitherto been very much in proportion to the importance of that truth, and to the use that they have made of it afterwards. This has been the case with all other sciences and subjects, and there is nothing in the science of plants to make it an exception. It is true that the Linnæan system made its way rapidly, and with comparatively little opposition; but it did so because it went lightly, and there was little in it about which to dispute.

When the Linnæans came to the proper science of the matter, they found as much difficulty as has been felt by others; and it was the wish of avoiding those difficulties, or rather of clearing them up, that led to the adoption of the natural system. It may be that, in some cases, the promoters of that system have pushed it a little too far; but it would be injustice to accuse of mere love of innovation those whose object and reward has been the discovery of truth.

Such is an outline of the principles of the natural system; the details are hardly yet matter of philosophy; and they are already to be found in the introductions, catalogues, and *prodromi;* nor could they be embodied in a very popular shape, even though the embodying of them, in such a shape, were necessary. But it is not necessary. They answer their proper purpose better where they are; they are easily accessible by all to whom they may be useful; and, therefore, what has been said may, probably, suffice to make a few, to whom the wild world has hitherto seemed a wilderness, look upon it as at once a garden and a library; and that object may, probably, be facilitated by casting a rapid and sketchy glance over some of the more interesting of those orders of plants that are established as natural.

SKETCH OF THE NATURAL ORDER CONIFERÆ.

CEDAR OF LEBANON

IN THE ROYAL ARBORETUM, KEW.

Height, 40 feet; circumference of the trunk, 11 feet; spread of the branches, 33 feet.

he
ld
ter
ot
a-
out
ed,
tial
out
ffer-
t all
eties
uit-
it
al
,
und, in
egions of the
ness is not an absolute
, because that varies with the
untries, and the manners of their inha-
ts. As little is priority of growth in any place;

CHAPTER VII.

SKETCH OF THE NATURAL ORDER

CONIFERÆ.

THERE is some difficulty in deciding upon the order of plants with which a popular sketch should be begun; because it is desirable that the character should be popular, and, at the same time, not only not at variance with the more recondite scientific character, but leading to that character by inviting but certain steps. Besides, as the orders are founded, not on entire and absolute characters, but on partial differences, one order cannot be understood without some reference to other orders. Some of the differences are also very nice; and if they be at all alluded to, there is danger of error, if the niceties are not gone into, with a minuteness not at all suitable for popular purposes. For these reasons it seems desirable to begin with an order, the external characters of which are broad and conspicuous, found in most parts of the plants, and at all seasons of the year; and of which the plants are found, in some of their species, over most regions of the world. Precedence in usefulness is not an absolute ground of preference, because that varies with the climates of countries, and the manners of their inhabitants. As little is priority of growth in any place;

because, although in some places we can trace a succession of predominant races following each other, the period of accurate observation is too short, as compared with that between the fossil plant and the present vegetation, for enabling any certain conclusion to be drawn. All things considered, it is probable that the *coniferæ*, with which, in some of the firs, every body is more or less familiar, form the best order with which to begin. They are conspicuous in their size, peculiar in their form and colour, both in the leaves and the bark; and as they are, with very few exceptions, evergreens, they can be studied at any season. They mark the vegetation of certain spaces that can be traced for long distances on the map; and they are generally accompanied with peculiarities in the soil, the climate, and the other vegetation, which render them a sort of key to the whole natural aspect.

Their uses in the climatal economy of nature are, probably, greater than those of most other orders; and, in value to man, they are inferior to none. Length, straightness, stiffness, and lightness, are the characters of many of their stems; and, but for the coniferæ, it would not be easy to find even a tolerable mast for a ship of ordinary burden; or to construct a building of equal strength and durability, without double the expense of masonry. Among them, too, it is possible to select timber which shall last just as long as is wanted. Some are of so fleeting duration, as to be decayed in a very few years, even in climates which are not the most destructive of timber; while others appear to be proof to all the natural agencies by which that substance is usually decomposed, and yield to nothing but forcible mechanical division or combustion; and some of them resist the fire to a very wonderful degree. Some of them maintain their green and growing state for several centuries, and on that account, by nations so far apart as not, in all probability, to have borrowed their customs from each other, they have been, and are still, planted over the graves of the dead, as the fittest material emblems of immortality. The timber of some is of far longer duration: the funereal cypress has been said to last for upwards of a thousand years; and the cedar (probably the cedar of the Himalaya mountains, *Deodara*,) for a very long period. The last-mentioned timber is, indeed, among the most indestructible of known substances. It is mentioned that, in some ancient structures in India, the date of which was lost in the distance of years, and the stone of which had yielded to the saline and sultry atmosphere, the bandings of Deodara beams, with which the masonry was united, were as fresh and sound as if they had been newly fitted.

Though the coniferæ cannot be considered as one of those orders of plants upon which mankind mainly depend for food, yet they are not wholly useless in that respect. The seeds in some of the species, and the *cambium* in others, make in some parts of the world no bad additions to or substitutes for bread. The resinous secretion of very many coniferæ (which is, generally speaking, a compound of resin and essential oil), is, under the various names of pitch, tar, turpentines, and balsams, of extensive use in the arts; especially in protecting timber from the action of the water, and in brightening its surface and protecting it from the air.

Many of the coniferæ, and some that are very valuable for their timber, form plantations better adapted for affording shelter, especially winter shelter, than any other order of trees. They rise faster, are more branchy, less flexible, and more constantly a defence against storms, than any other family; and their timber is also much more durable in its young state. These are some of the claims which the coniferæ have to precedence; and many others will appear in the following sections.

SECTION I.—GENERAL CHARACTERS.

The readiness with which the coniferæ are distinguished applies as well to the sub-divisions of the order, in respect of each other, as to the whole order in respect of all other vegetables. A pine, a spruce, and a larch, are much more easily distinguished than an oak is from a chesnut, or an elm from a hazle, even when they are, as nearly as possible, of the same size and shape. The bark, the leaves, the tint of colour, the cones at any stage of their growth, the general aspect of the tree,—any and all of these are decisive at a glance.

The more minutely that we examine them, their difference from all other plants, and their general agreement with each other, become the more striking. With the exception of the *cycadeæ* (including among others some of the sago-plants), the coniferæ are the only flowering plants of exogenous growth that have the seeds naked. By seeds is the only means of multiplying one important division of them; and, in most of them, the success of other methods is precarious. At the same time, there is not in the whole order any thing that can be considered as a perfect flower,—that is, a flower containing both the fertilizing and fertilizable parts. Nay, there is nothing which can, in very strict language, be called a flower at all—if a flower is to be considered as any thing more than pollen, an ovule or rudimental seed, and some sort of receptacles on which these are produced. The other parts, both of the *amenta*, or pollen flowers, and of the cones *(strobili)* or seed-flowers, are scales or bracteæ of some description; and although in some of the cones these are hard and lasting, in the pollen flowers they are generally of no very long duration. There is no calyx, no corolla, no stamens, no anthers (properly so called), no stigma, style, or ovary; nothing but scales, pollen, and seeds. It is true, however, that these are all that is essential,—all, in fact, of which the use is known with certainty.

About half the species used to be described as monœcous, and the other half as diœcous; but so far as they have been fully examined they are monœcous; and that renders it at least extremely probable that that character belongs to them all. But that character being one of mere form is not of much importance. It is probable that the notion of their being diœcous may have arisen from the fact, that there is often pollen on the plant and no cones, or cones and no pollen.

The vessels that contain the pollen (or, as they are called, the anthers), are single, or in small clusters, round a rachis or stem. Sometimes there are two lobes, sometimes more, and the anther is sometimes an undeveloped scale for part of its length, or on the one side; but those variations are not of much importance. The anthers burst outwardly and discharge the pollen, which is often so abundant as to get the name of "brimstone rain."

When the seed-bearing flowers are solitary, the external tunic of the seed sometimes forms into a pulp, as in the berries of the common yew. In the solitary flower the position of the seed is erect; but in those genera that have the flowers collected into cones, the envelopes of the seeds never take the form of berries, but remain naked, adhering to the scales, and in an inverted position. Each scale is separated from the one under it by a membranous plate or bractea. When the cone is young, and before fertilization, these are coloured at their margins, there is an aperture between the bractea and the scale, and the position of the cone is often upright. After fertilization these apertures close, the scales become thick, the bracteæ are in some cases obliterated, in others they remain projecting from between the scales; in some genera the cones become pendulous, though in others they retain their upright position. As the seeds ripen, the scales become hard and ligneous in some, and tough and leather-like in others,—and there are few of the species in which the scales open and the seeds escape till the cones have separated, and been for some time exposed to the weather. In the seeds the embryo is embedded in an albuminous matter, consisting of farina with a greater or smaller admixture of resin and oil; when these (more especially the oil, which has an acrid taste, and, generally speaking, a powerful effect upon the kidneys) are removed, which is easily accomplished by roasting, the farina becomes edible and nutritious, differing little in its nature from the farina of other seeds. In some of the genera, as the *araucarias*, more especially Araucaria Brasiliana, the resin and oil in the seeds are in so small quantity, that the seeds may be eaten without dressing; and such seeds are sold as nuts in the markets of Rio Janeiro and the other towns of Brazil. In others, again, the quantity of oil and resin (turpentine) is so great, that the seed seems altogether resinous,—as is particularly the case with the seeds of the Indian cedar (deodara). In some, as in the common yew, there is a deleterious principle; and children have been poisoned by eating the berries, which are rather inviting, in consequence of their fine red colour and sweetish taste. It has been supposed that the poisonous quality is confined to the embryo, and that the albuminous matter and the pulpy tunic are quite harmless. Some eminent botanists are, however, of a different opinion; and certainly the safe way is to avoid the berries altogether, as the pulp is neither racy nor nutritious. The embryo has its plumula to the base of the seed, and is furnished with opposite cotyledons, never fewer than two, and often in considerable numbers; but the embryo has a direct mammary connexion with the albumen.

The cones are produced at the same time and place, as the branch buds; and the character of the plant is found in their structure. If the leaves (whether singly, or several in the same sheath), are so placed on the twigs as that their insertions can be traced in a double spiral (that is, a spiral toward either hand) round the twigs, the same character may be traced in the scales of the cones. Nay, the very same character extends to the branchings of the tree, though there the regularity of it is liable to many contingencies. The branch may be destroyed in the bud, or the bud may never be formed, in consequence of inferior vegetative power in the side of the stem upon which, otherwise, it would have been found; or it may be destroyed by accident, lopped off by design, or strangled by the active vegetation of the stem. These causes operate such a change in the appearance of trees, that one who knew nothing of the more minute characters, would hardly believe that a young and vigorous Scotch fir, with its branches perfect to the ground, was the same species with the tall and branchless trunk, that stands alone by some ruin, with one or two little bonnets of leaves at the top, not bigger to appearance than rooks' nests.

This character is, however, a most important one, both as from it the tree may be known, and as it establishes the fact of a specific character in all parts of the tree, which may be modified, but not obliterated; and which is at once the production and the proof of one mode of vegetation, peculiar to the species, and therefore its true natural character.

This double spiral is produced, by the branches, the leaves, and the scales, alternating with each other in their successive whirls; so that the individuals of each whirl fall on the middle of the intervals of that below. They do that most remarkably in the pines; and that is what might be expected. With the exception, perhaps, of the araucarias, the timber of the pines has the straightest vessels, and, in proportion to the cement of turpentine in it, is the most easily split; and, probably, the splintery character in the araucarias is owing more to the want of turpentine than to any deficiency of lateral cohesion in the vessels. Well, from the straightness of the vessels in the pine, each whirl must occasion a lessening of the vegetative action, immediately over each of its members, which will be the same as an increase in the intervals; and as the new production is the result of that greater action, it must, as a matter of course, take place at those intervals. The turns of the spiral will be more open in proportion as the growth of the tree is more rapid; but we may consider it as a general law, that trees which have straight vessels, and branch in horizontal whirls, must have the members of those whirls alternate; and, further, that if there is a destruction of the lateral buds on any side one season, there will be a tendency to more vigorous budding and branching on that side the next season.

The spruces have this character less marked in the branches and leaves than the pines, and their cones have not the spirals so perfect. Their vessels, also, are less straight, and their timber not so easily cleft as that of the firs. The larches and cedars, which have the leaves in tufts, and the wood with still more lateral cohesion, have the scales of the cones imbricated, so that the spirals are not easily traced. A much closer imbrication takes place in the cones of the araucarias; and so much does it agree with the character of the leaves, that, in the *imbricata*—upon the twigs of which the leaves are thickly serried—the scales of the young cones very much resemble leaves in appearance. In the remaining divisions of the order, in which the habit of the pine is still more widely departed from, and there is hardly a trace of branching in whirls, no spiral appears either in the insertions of the leaves, or in the scales of the cones. From the Scotch fir—which never forms a lateral bud, except those that surround the terminal bud of the shoot, and are produced at the same time with it—to the yew and the arbor-vitæ, in which such buds are often found, there are many gradations of this character; but the change is so constant in all the structures, that the value of the character is thereby established. The only anomaly is the *pinus variabilis* of North America, and perhaps one or two others, which *appear* to put out little abortive branches from the sides of the knots; but these have not been much examined; and from the inconstancy of the leaves, which are sometimes two, sometimes three, in a sheath, and some characters of the timber, which is intermediate between that of the Scotch fir and some of the softer firs of America, it *may* be possible that the variabilis is a hybrid.

The leaves of the coniferæ form a good character, both popular and scientific; both of the whole order, and of the divisions of it. They are, in their individual shape, uniform upon the same species; but they vary considerably through the whole order. In the firs they are linear or needle-shaped, though one Chinese species—*pinus lanceolata (Cunninghamia* of Brown)—has them lancet-shaped. On the spruces and yews they are broader; the breadth increases in the araucarias; and the dammanas have lancet-shaped leaves approaching to ovate. The evergreens generally have the leaves of rigid texture, smooth surface, and very rarely toothed at the margins; the deciduous trees have the leaves of softer texture and paler green; and the deciduous cypress has them in two rows, and thence it is called *disticha*. The vessels of the leaves are all straight, and do not form reticulations like those of trees that produce buds on the bark. The minute anatomy of about 150 species or varieties would be a work of much labour; but, so far as examination has gone, there is reason to expect the same deviations from absolute straightness in the vessels of the leaves as in those of the wood.

Though some of the coniferæ are generally found with flat tops, and others tall and spiry, yet as those differences occur in the same species, where they are obviously occasioned by differences of situation, they are to be considered more as accidental than as natural characters; but they have some foundation in nature, though that does not appear to have much connexion with the general characters, as both habits are found in the same genus. Thus, the Norfolk Island pine *(araucaria excelsa)* is a spiry tree, while the Moreton Bay pine *(araucaria Cunninghami)*, which much resembles it in other respects, has the top flat. The cedar of Lebanon, too, forms flat masses of branches and leaves, that are piled like one dense cloud over another, while the Indian cedar is said to be more spiry. Much of the form depends on the situation: if the plant stands alone, it is flat; if in a close forest, it runs up, and the lateral branches decay. Now the Moreton Bay pine is not in groups, but scattered through a forest of trees, of very inferior magnitude, on the banks of the Brisbane river, while the Norfolk Island pine forms groups. In like manner, the cedar of Lebanon is generally detached, or mixed with trees of inferior growth; while the Indian cedar is in dense forests, either of its own species, or of a mixture of the pines of the Himalaya. In some cases, however, as in the larch and the spruce, solitude does not so much change the spiry character of the tree.

The general habit of the coniferæ may, therefore, be considered as the producing of one central stem or axis of vegetation, the form of which is conical; or, more strictly speaking, made up of a series of cylinders terminating at the branches, and each containing one layer less than the one below it. The relative diameters of these successive cylinders bear some proportion to the size of the branches at their upper extremities, although the diminution of the stem is not so great as the increase of the branches, if these have free access to the air and light. The reason is obvious: the action of the exogenous tree, in the formation of timber, is not in proportion to the section of the stem, but to the circumference at the union of the wood and bark; and, as the circumferences are as the square roots of the surfaces, it follows that there must be twice as much circumference, and therefore twice as much space for the cambium to be formed in, in four branches of six inches diameter each, as in one stem a foot in diameter. When the branches are taken off, or otherwise become obliterated, the part of the trunk below the branching takes the form of a cylinder; for though the number of layers of wood is never so great in the upper as the under parts (if at any time there have been branches), yet the external layers are much thicker at the top, as they are nearer the action of the leaves; that cause, however, renders the upper part of the tree more spongy, and not so valuable timber as the part toward the root.

The coniferæ that deviate most from the character as taken from the pines, are the cypresses and yews, many of which are branched in their very young state, and continue branching during the period of annual growth: but even these have the general character of the order in the wood. That character is something between the endogenous plants and the exogenous that have the seeds enclosed in a pericarp. Like the latter, the coniferæ have pith, wood, and bark, all distinct, and those that extend and branch by terminal buds only have the pith ramified through the whole structure; and, they agree with the endogeneæ in having the spiral vessels few, and the lateral cohesion weak.

Though the bark varies very much in appearance in the different species, there is a general character that runs through the whole; though, amid so much variety, it would not be easy to point out in few words in what that character consists. When young, it is marked by the insertions of the leaves, the bracteæ, or their remains; and, in some, by the leaves themselves, which continue to adhere to the bark after they have become merely dry scales. In most of the species the epidermis scales off in patches, and, like the wood, shows an intermediate character. It is not fibrous in the direction of the circumference, as in many other trees, neither is it fibrous in the length, as is the case with many of the endogeneæ. The colour alone, the reddish brown, different from the tint of the bark of all other trees, is of itself a sufficient popular character.

The general character of the roots is rather to run into breadth laterally than to penetrate deeply into the ground, and they have little or no tendency to put out suckers. They, of course, partake of the general characters of the wood; but their vessels are more convoluted, and, in some instances, much more filled with resin, and therefore much more durable.

Such are some of the general characters of the coniferæ; and any details that are consistent with the nature of a sketch, can be better given in noticing the more conspicuous genera. It may be remarked, in passing, that the order comprises the most abundant, the most majestic, and the most useful trees in nature. Generally speaking, they abound in those places where other trees are not found, and clothe vast tracts of country with a perpetual foliage. The margins of the polar snows are, in the northern hemisphere, a favourite locality, where they stand in thick phalanxes to break the fury of the storm, and afford shelter to more lowly or delicate vegetation. In the north of Europe, of Siberia, and of America, if the soil near the regions of extreme cold be not fit for the production of pines, that cold invades regions much farther to the south than where there is such a shelter. In the southern hemisphere there is no such cold, as there is no land of any considerable dimensions which reaches so high a latitude as to have an atmosphere very long below the freezing point, and thus the hardy pines of the north are not found there; but, as far south as the Strait of Magelhaens, the cupressinæ and some other species rear their evergreen groves, and afford shelter to the soil, and arms and utensils to the inhabitants. In Australia, singular, and in many respects singularly sterile, as that country is, we meet with the Huon pine in dense masses in the ravines between those wild cliffs which the south coast of Van Dieman's island raises against the southern waves. And it will be at once seen, that it is to the dell or the ravine, and not to the mountain and the promontory, that the protection is required. It is on the low surface that a wind beats with the greatest fury; because the lower stratum of the air has the greater specific gravity, and, also, because a dell or ravine collects the wind like a funnel; while against a bold shore the current of lighter air over the surface has its velocity diminished by that which is turned upward, after beating against the face of the steep. Thus the coniferæ, in their close masses, with their evergreen leaves, are protecting fences to those parts of the earth which are best adapted for vegetation, but which, except for them, would be swept to the very rock by the fury of the wind. And here one cannot help remarking how admirably the coniferæ are constructed for the performance of these important functions. Their compact and slender leaves are not liable to be torn, and their spiry forms are not liable to be uprooted, as would be the case with trees of larger foliage and more extended heads.

If we follow them into the interior, we find that they still perform similar services. The edges of the mountains, slope over slope, and race following race, according to the general climate or the particular elevation, are the places where they are native; and they afford protection alike from the rude and restless winds that are necessarily met with in such places, and from the destroying avalanches of snow which sometimes descend from the mountains. There are some other circumstances connected with more general views than those that have been mentioned, but they can be noticed with more advantage in another place. It is not a little curious that the coniferæ, which are a sort of intermediate in their whole structure and characters, should have their station upon the earth's surface, intermediate between barrenness and fertility. But that is something more than mere curiosity; it is another proof that, in all the variety of nature, the purpose is one, and so is the Maker and Governor.

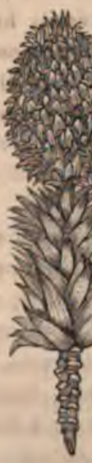
SECTION II.—NUMBERS—SUB-ORDERS—ABIETINÆ.

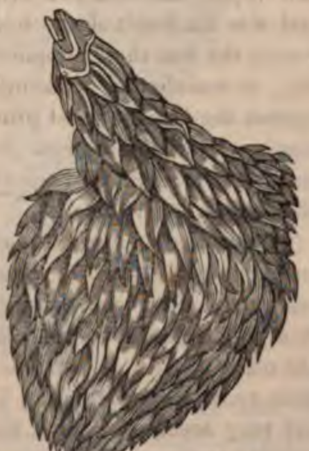
The total number of species of the coniferæ, named n the books, is somewhere about 150; and as there are nany mountainous regions that have as yet been but mperfectly examined, or not examined at all, it is by no means improbable that considerable additions may yet be made to the catalogue,—the more so, that some of the species, and among these several of the largest and most recently known, are confined to very narrow localities. Of a considerable number of those that are mentioned, very little is known, and it is possible that many of them may be mere varieties, altered by climate or other circumstances; but the settlement of these points belongs to the professional botanist, and is mentioned merely that the popular student may not believe implicitly beyond the facts that have been observed. They are all trees or shrubs of some size or other; and in favourable situations the greater number of them attain considerable dimensions. The ones of smallest growth usually grow very slowly, and have their timber very compact and hard. The giants of the order (and some of them are truly gigantic) are, generally speaking, more spongy, and, as timber, are all local trees; and, with the exception of the first species, they are confined within a small compass each, and not far from the same parallel—that is, about 23° or 24° south latitude. Though no conclusion has been hitherto drawn from it, it is a curious fact, that there should be a well-defined and rather singular genus of plants ranged round the parallel of nearly the southern tropic, and at wide distances from each other, while not one of these bears much resemblance to any other vegetable of the district in which it is found. All the species are diœcous. The pollen being contained in an amentum of a considerable number of scales—often ten or twelve; and the seeds in cones, imbricated in proportion to the habit of the leaves. The seeds have no covering but their proper tunics, and are something wedge-shaped. Though generally described as diœcous, they are most probably all monœcous.

1. *Araucaria imbricata.*—The Chili pine.

For the habit of the tree, see the vignette on the title of this volume, which is a portrait of one in the Royal Botanical Garden at Kew, by far the finest and largest specimen in Europe. At present (1831) it has been about thirty-five years in its present locality. It stands in the open air, and has borne some hard winters, though of late years it has been protected by a wooden tent in the severe weather. In the young twigs and the leaves—the union of which is so intimate that they seem to form one entire piece, and have no distinction of bark, or even of pith, the epidermis being the only apparent envelope—the resinous matter is rather abundant. It is limpid, and has very little pungency of taste. When older, the bark forms between the wood and the leaves; and the latter, which stand erect upon the young twigs, flatten, and lie upon the bark like scales; nor do they separate till long after their action has ceased.

Of the following figures, the first represents the pollen amentum, and the second the seed-bearing cone in its young state; with these and the vignette, a tolerable notion may be formed of the habit of the tree.



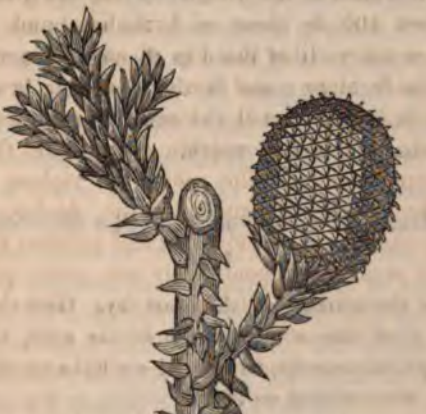


The specimen alluded to is but a small tree for its age; but when it is considered that the hemisphere and the seasons have been changed to it, and that its growth in its early years must, in consequence, have been very slow, no conclusion can thence be drawn respecting the size that it may attain on its native Andes. It is said to occur in considerable numbers,—indeed, to form vast forests, in the central valleys of the southern Andes. In those situations it reaches the height of 150 feet, of which the first 100 is clear of branches, and the remainder spiry, like the top of an old spruce. It also stands alone; and the rectangular branching, the thick twigs, from the close setting of the leaves, make it, no doubt, a majestic object amid the rocks and rapid condors, the snow, the violent storms, and the blazing volcanoes of the Andes. Then, during the season of cloudless and galeless tranquillity, it must come beautifully out, when projected against the transparent Chilian sky. But the forest scenery of the southern Andes is still, in some measure, an unreaped harvest,—whether rich or not, observation must discover.

The bark, the external portion of which, in the old trees, resembles cork in appearance, contains a white resin; the wood is of a yellowish white colour, mottled and compact when recent; but if it resemble the other species, it contains little or no resin, and thus cannot be durable. The trees are, besides, not very accessible; and, though there be a considerable trade carried on in the timber of some coniferous trees, from the coast, near Araucania, from which country the genus is named, it is probable that the whole of that is from cupressinæ.

2. *Araucaria Braziliana.*—Brazil pine.

The following figure represents the seed cone, and a portion of the twig, one year older than that on which the cone is borne. The twigs are much less imbricated than those of the former species, and the character of the cone corresponds.



This species is found occupying a small track of country not far from Rio; and elevated, upon the average, about 1000 feet above the level of the sea. It is a region of lightning and storms, and many of the trees have their tops scathed by the former, and their branches broken and tattered by the latter.

The Portuguese are an incurious people in matters of science, and therefore not much is known about the qualities of the timber,—though analogy would lead to the supposition that it will splinter and decay as soon as it dries. The trees attain the height of 70, or some of them 100 feet; but they want majesty, and the wildness of desolation is probably the most striking character of the place. As has been already mentioned, the seeds are sold as nuts; and a want of resin in the seed is a sign that there is little or none in the timber. It is by no means improbable that the same tree may grow on the mountains farther south.

3. *Araucaria Cunninghami.*—The Moreton Bay pine.

The araucarias of the east are trees of even larger dimensions than those of the west, although we implicitly credit, as indeed we have no reason to doubt, what is told us of the forests in the Andes.

In its young state, the leaves of the Cunninghami are very minute, and the young twigs might almost pass for "changed leaves." They are then drooping, and flattened horizontally, though some of the leaves are vertical. As the twig increases in growth, the leaves become more uniform on all the sides; and when more advanced still, they become imbricated.

The locality in which it has been hitherto found is very limited. The large trees are met with in close woods of other and very different genera, on the immediate banks of the Brisbane river; and there are smaller trees in the back country scattered here and there on the wastes. Near the river, the trees are rather numerous, though not close together; and, as they rise high above the other trees, the whole has the singular aspect of one forest overtopping another. They are handsome, and rise to the height of 120 or 160 feet. The wood, too, when fresh cut, is clear, uniform in the grain, works well, is compact and light, and promises to be serviceable. If used green, it stands very well as masts; but in very short time, that is, the moment they become dry, they begin to rot, and are unserviceable. Notwithstanding its apparent closeness and uniformity of grain, there is no lateral cohesion between the fibres, and no resin in the wood, either to cement the fibres or to resist decomposition. For temporary purposes in carpentry, it may be used on account of its size, and of the facility that there is both of obtaining and working it; but if the purpose is not very temporary, and the application near the forest, it is hardly worth the labour.

4. *Araucaria excelsa.*—Norfolk Island pine.

In point of magnitude the *excelsa* is worthy of its name, for it is not easy to imagine a more majestic tree. It is scattered over most parts of the little island from which it derives its English name, and grows in the valley, on the ridge, and even on the very summits of the lofty cliffs. In some of the latter situations it is peculiarly picturesque. A tree of vast diameter, and towering to the height of nearly two hundred feet, may be found stuck, as it were, into a cleft on the brow of the precipice, sending down its roots to the distance of many feet, and insinuating them into the crevices, so as to resist the storms that blow and beat around the island. In many instances, large portions of the tops are broken off by the violence of these; more especially on those trees which are near the summit; but where the soil is a little deeper, and the trees have not met with casualties, they are immense; particularly two, called "the Brothers," between which the road passes.

The timber is, however, far from durable, and it is very brittle, so that masts or spars of it would be of little or no service; and thus, like its congener at Moreton Bay, it is devoted to humbler purposes, —the boarding of huts and boats. As is the case with the Cunninghami, and probably with all the araucarias, there is no turpentine or other resinous matter in the wood. A considerable quantity exudes from the bark, and that is of a milk-white colour. Attempts have been made to render that resin useful as a substitute for pitch for boats, but without success, as it will not melt, or even burn. Taking them as a genus, it may be said of the araucarias, that they are among the most gigantic and the least useful of the vegetable tribes. In the few and limited districts in which they are found, they are certainly very ornamental, and impart a very peculiar character; and as they do not grow very close, and seldom shed any leaves, they allow less lofty but more useful trees to grow between them; but one can hardly regret that in range they are so limited.

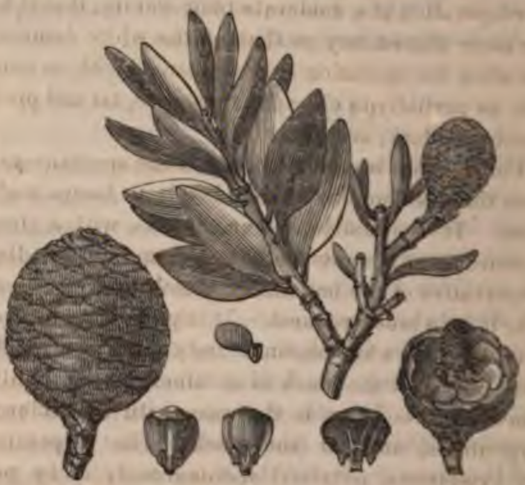
That any of the three species last enumerated would stand the winter in this country is doubtful; but in all probability the *imbricata* would in warm and sheltered places; and, were that found to be the case, (of which the plant at Kew is a proof), it would make a good variety in shrubberies,—only the importation would be troublesome and expensive,—more so, probably, than the plant would be accounted worth, after it had ceased to be a rarity.

The Norfolk Island pine was a great favourite with the late Governor King, who resided for some years in Norfolk Island, and it has been adopted by his family as their emblem or crest.

§ II.—DAMMARAS.

The dammaras are, like the araucarias, very limited in species, and each species is confined to a single locality of trifling extent. As the localities of the araucarias are found in a little zone girdling the southern hemishere, so those of the dammaras are found at the extremities of the line, some three thousand miles in length, lying from north-west to south-east, along the Indian Ocean in the same hemisphere. Of the dammaras there are two: Dammara *Orientalis* (the pitch-pine of Amboyna), and Dammara *Australis* (the *Kawii* tree of New Zealand.) In some of their characters, those two trees approach much nearer to the pines than the araucarias. They abound much more in resin than the araucarias, and the timber is far more durable; but they have opposite leaves, of a lancet-shape, which is not a habit of many others of the order. In the woods of Amboyna (which is one of the choice gardens of the spicy east), it can hardly be said that the dammara forms a striking character in the landscape, though it is in many respects a useful tree; but in New Zealand, although there are other very large trees, the dammara stands conspicuous, if not in size, at least in value.

1. *Dammara orientalis.*—Amboyna pitch-pine.



That species is chiefly valued for its resinous secretion, which is not perfectly analogous to the turpentine of the north, yet consists like that of an oil and a resin; and it occurs either hard, that is, with the oil evaporated by natural or artificial heat; or soft, that is, with the oil still in it. The dammar of commerce, of which it forms not an unimportant article in the east, is of two kinds—dark-coloured, and white; and perhaps it may be obtained from more than one plant; at all events, it is obtained in other places besides the island of Amboyna. From the mere circumstance of the two colours it would not, however, follow that these were the products of different trees. The crude turpentine of pines is white, even after it has had its essential oil so much reduced by evaporation at a moderate temperature, that it has the same consistency as that of the white dammar; but when the operation is accompanied with so much heat as partially to char the substance, tar and pitch, which are dark, are the result.

The dammar is understood to exude spontaneously from the trees, and to be found in large lumps under them. It is usually hard and brittle, with a glassy fracture; but it melts well, and forms an excellent preservative of the bottoms of vessels, for which purpose it is in much request. It is probable, however, that it is the white dammer only that is an exudation; and that the black is obtained by the distillation of the wood; as is the case with the different turpentines, and tar and pitch. The turpentines are exudations, obtained spontaneously or by perforating the trunks of the trees; and tar is gotten by distillation; in the course of which process charcoal is formed, and should render the product a better preservative. As preservatives against insects there is probably not much difference; because, though pungency may be gained by the pyrolignic acid that is formed, as much is lost by the evaporation of the essential oil.

2. *Dammara Australis.*—The *Kawii* tree.

The dammara of New Zealand is a noble tree, superior in its timber, and greatly superior in its dimensions, to that of the tropical parts of the east. That may be, to a considerable extent, owing to the difference of climate. That difference is more one of general temperature than of any thing else; for in other respects the places resemble each other. Both have climates rather humid; both have varied surfaces and abound in streams; so that both are highly favourable to vegetation. It is true that the finer spices and fruits of Amboyna are unknown in New Zealand; but it is equally true, that there the groves and glades, especially those of the northern island, form a striking contrast with other places on the same parallel of latitude. Yet it is worthy of notice, that the Illawarra district of New Holland, which lies nearest to New Zealand, should be remarkable for its botanical riches; and the same may be said of the portion of South America that lies nearest to New Zealand on the east. At both of those points there is good timber, and a vegetation tropical in its character as compared with the latitude.

The dammara is diffused over New Zealand in considerable numbers, both on the dry ridges of hills and in the ravines; not in close forests, however, but in groups. Its habit is straight, and many of the specimens rise to a hundred feet before there is one branch; and the whole height is often 200 feet, with a corresponding diameter. The wood is not very heavy, and it is compact, tough, and easily worked; so that it is highly valuable in ship-building, as masts and spars for vessels of any size may be made of it.

It is the naval timber of the natives, who hew the vast trunk into canoes, sometimes more than eighty or ninety feet in length.

It is probable that the colder climate keeps the resinous matter much more in the wood than is the case with the dammara of Amboyna; and to that circumstance are probably owing the greater strength and durability of the timber, as well as the larger size of the trees.

It seems a sort of law among the resinous coniferæ, that, of any one species, the timber is the better, the colder and the more moist the atmosphere in which it is produced; though, with respect to species, the best ones are not always in the coldest latitudes. One might conclude from the nature of the resin that it would resist humidity better than long seasons of drought and heat, as these act much more upon the resin: that it is expanded and rendered thinner by the heat, and thus it ruptures the cells and vessels, and escapes into the air, where the oil evaporates, and the resin is left in a brittle, or even a powdery, state. Those who have been much among pine plantations, especially at that stage when their growth is most vigorous, must often have seen the effects of long-protracted drought in the early summer, in a white efflorescence upon the plants, and when the heat of the sun was strong, in an increased scent of turpentine in the air. With trees that contain gum and not resin the case is the reverse—they bear heat and drought much better than humidity.

We have some remarkable instances of that in the geographical distribution of trees in all quarters of the world. The coniferæ are found near mountains or in rainy places, and the gumniferous trees on the arid plains or uplands. We have the Huon pine and the Adventure Bay pine in the south and south-west of Van Dieman's island, and the araucaria at Moreton Bay; while those parts of the interior of Australia that are rich enough for being covered with any thing but "brush," produce different species of eucalyptus. The arid countries from the Nile to the Indus produce many acacias and other gum-trees, but no pines; while pines and cedars abound to the eastward of the upper part of the Indus. So, also, there are gum-trees in the central parts of America, while the coniferæ are principally toward the north and south; and in the north the pines trend to the south-west, which is known to be a region of heavy rains.

SECTION III.—SPRUCES.

The coniferæ that have been hitherto noticed are confined to particular spots, and the period during which they have been known to Europeans is comparatively short. The spruces, the pines, and the larches, on the other hand, are found, or have formerly existed in some of their varieties, on all the ridges of mountains in the northern hemisphere, while others cover, or have covered, sandy or swampy tracts. They are, therefore, matters of history as well as of present description; and, as is sometimes the case with other matters of which there is ancient as well as modern knowledge, there is some confusion in the names. All the three sub-genera, of which the popular names have been mentioned, are indiscriminately called pines. They are also called firs; and those to which we have given the popularly descriptive name of spruces, are the same to which the name of *firs* has been more directly applied by some botanists. This is not mentioned with a view to the discussion of the names of trees as a matter of etymology (for it is possible that the Latin *pinus* and *abies* may have meant the same tree or trees—all resinous trees used in ship-building), but merely to turn the edge of any objection that might be brought against a departure from the received nomenclature, by stating that the very best authorities are a little at variance with each other; and that the distinction which we have made is merely a popular one, founded on the marked differences in the general appearance of the trees.

The spruces or firs are, in appearance, both externally and internally, intermediate between the araucarias and the pines; like the former they have the leaves single, without any sheaths, thickly set upon the twigs and persistent; they have the timber light in the colour, except in the knots that arise from, or rather are the remains of strangulated branches; the bark is thick, and not so liable to crack and scale off as in the pines; the rings in the wood are not so marked as those in pine, and the wood is less elastic, strong, and durable. The resin, too, is more colourless, and probably does not contain so much essential oil. The lateral branches are stronger in proportion to the stem than those of the pines; the stem is rendered more gnarly at their insertion; and, unless in very confined situations, the branches remain, and give a spiry character to the tree which it retains in mature age, and does not become broad-topped like the pines. Like the pines, the spruces are monoecous; but the cones are long, spindle-shaped, and pendulous, of a reddish colour, and have the scales imbricated, and tough, and flexible compared with those of the pines. The single leaves, not forming, as it were, one substance with the twig in its early stages, but inserted on a bark different in texture and colour, at once distinguishes the spruces. No true pine has single leaves; the araucarias have the young leaves so concealing the twig as apparently to form one substance with it; and the branches, coming off at greater angles, together with the whole appearance and habits of the trees, make the spruces easily distinguished from the yews.

The spruces are very abundant and widely diffused, forming part of almost every pine forest in the northern hemisphere, from the shores of the polar seas to the tropic. Sometimes they form dense forests; and when that is the case, such forests are, from the persistence of the branches and the thickness of the leaves, absolute darkness and shade. *Vaccineæ*, mosses, and many other plants, grow in pine forests, but nothing, not even a lichen, will grow in the shade of thick spruces. From their greater abundance of leaves, the spruces have much more general and active vegetation than the pines; they are not so subject to casualties, and they attain a greater size. They also appear to bear heat and cold better. In the western part of Lapland, toward the North Sea, the spruces are not found so high upon the mountains, or so far to the north, as the pines; the limit of spruce in Norway being about 69° north latitude, while that of the pine is about a degree more. As we proceed eastward, the case is different; for in Russian Lapland, and especially in Siberia, spruces are found farther to the north than pines. Is is that they are better able to stand the severe cold of the Siberian winters? Probably not: the drought and heat of the Siberian summers, when the sun beats continually upon the arid surface of the *steppes*, is probably the cause why pines take a situation nearer the Altaian mountains than the spruces. The greater number of leaves upon the spruce enable it to draw nourishment from an atmosphere much too dry for pines; and as spruce forests shade the soil more than those of pine, the roots suffer less from evaporation. In America, spruces are found far to the north, although there they do not appear to be more northerly than the pines.

Spruces of one species or another are found girdling the whole circumference of the northern hemisphere, from the west coast of America eastward to the sea of Ochotsk; and they are found, from the limit of forest vegetation to as far south as about 42° in Europe, 30° in Asia, and 20° in America; so that the range in latitude may be estimated, in round numbers, at about 1900 miles in Europe, 2500 in Asia, and 2700 in America. But they are found only at particular points over those ranges, and always in higher situations the farther to the south. In Lapland, spruces are found at nearly the level of the sea, and they do not grow at so great an elevation as the pines. In the Carpathian mountains, spruces are found as high as 4500 feet; but they are chiefly in the valleys; and the hills between have stunted pines scattered over them. On the Alps one species of spruce is found as low as 600 feet above the level of the sea; and another grows at the height of about 5500. On the Pyrenees, the range is from about 4000 to about 6000. Spruces are found to the height of about 5000 feet on the mountains of Caucasus. It is probable that they do most grow so high upon the Altaian ridge; but the altitudes there have not been so well ascertained. On the Himalaya the range is from 6000 to 10,000 feet, or even to a loftier elevation. On the north side of those mountains, toward the sources of the Sutledge, pine forests are mentioned more than 15,000 feet above the level of the sea; and the trees in these are reported as being 24 feet in circumference, and 180 feet in height; that is, at an elevation above the level of the sea not inferior to that of the summit of Mount Blanc; and if some of the estimates are accurate, the locality of those pine forests is more elevated than the summit of Chimboraço itself. The bed of the Sutledge is "14,924" feet in height; the rocky boundaries are "5000" more; the villages of Kunawar are above the rocky boundaries, in a country the vegetation of which is exactly that of the north of Europe; and the forest of "gigantic pines" is above the villages. The villages are thus 19,924 feet above the level of the sea (if the estimates are correct); and so there is only about 1500 feet both for villages and forest, to give the latter the same elevation as Chimboraço; that is, 21,440 feet, which is 6000 feet higher than the limit of phenogamous vegetation on the American continent. The climate on that side of the Himalaya is very peculiar, and cannot be judged of from other climates; for at these villages the temperature, not of the direct rays of the sun, but of the air in a tent, was found to be 108° of Fahrenheit.

The spruces of America are, at least in the more northerly parts of it, in the valleys and on the slopes rather than the sedges; and in the central parts southward, towards the Gulf of Mexico, they are comparatively few. They are found again in Mexico, especially near the Peak of Orizaba, which rises to the height of nearly 18,000 feet, and is in rather a stormy region. It is probable that the atmosphere of the central Andes, in Peru, is rather dry for being very favourable to spruces; the volcanic nature of the country no doubt conduces to the same effect; and the want of forests is one of the causes of the severer cold. In as far as evaporation is concerned, vegetation produces cold; but the plant elaborates its substance out of liquids, and even gases, and the conversion of these into solids must be attended with the production of a considerable quantity of heat.

There are a good many species of spruces, some found in Europe and also in Asia, some in Asia only, and some in America. The same species is not found on the eastern continent and in America.

The spruces could bear to be popularly divided into *spruces* properly so called, and *silver firs;* the former having the cones pendulous, and the latter having them erect, and often with the bracteæ lengthened and persistent. The silver firs have also generally white lines on the under sides of the leaves, from which they get their name of "silver." We shall enumerate them, however, as found in different localities; but it may be mentioned that the silver fir belongs to countries farther to the south than the spruce, though the range of both is so great that they are found in the same forests.

EUROPEAN SPRUCES.

There are two spruces natives of Europe—the Norway spruce *(pinus abies)* and the silver fir *(pinus picea)*. That, however, is certainly a preferable system which separates the spruces from the pines, by making them two genera—*Abies* and *Pinus*. These are found chiefly—the first most abundantly upon both the most northerly; and the second upon the most southerly, or, perhaps, rather the central mountains of the European continent. They also both pass into Siberia, but they have not been met with, at least in the same species, in the south of Asia or in Africa; the spruces of Taurus and the Himalaya being different.

If we could, in a satisfactory manner, ascertain what effect differences of soil, temperature, and humidity, have on the habits and appearance of trees, it would be a discovery of the utmost importance both to the physiologist and the cultivator; but in the present state of our knowledge it affords but vague guesses, and even these are too theoretical for being introduced into a popular sketch.

Norway Spruce.

Though the Norway spruce *(pinus abies,* or *abies excelsa)* is found abundantly in the country after which it is named, yet that is not its only or its chief locality. It is found, perhaps more abundantly, to the eastward of the Scandinavian mountains; upon all the mountain ridges as far south as the Pyrenees, and eastward into the north of Asia; but it does not appear to like the air of the Atlantic so well as the pines; and, therefore, it probably never was native in the British islands, even when so great an extent of them was covered with pine forests, as must once have been the case.

The tree is easily known by its spiry habit, its strong branches in whirls, its thick-set leaves, of a strong dark green, four-sided, and very stiff and firm; and by its large pendulous cones, of an ovate spindle-shape, with rhomboidal scales, open and rather ragged at the margins. It grows rapidly; and in favourable situations attains the height of at least 150 feet; but it is not on that account entitled to the epithet of *excelsa*, even as an *abies;* for the silver fir of Nootka Sound, *pinus Douglasii, pinus taxifolia*, or (if that were not the name of the silver fir of Europe) *abies taxifolia*, is much more worthy of the epithet, as it rises to the height of 240 feet, and acquires a diameter of nearly 18 feet at the base. The timber of the spruce is light and rather elastic, and therefore it answers well for masts and spars; but it is not very durable; and it is not so serviceable when cut into boards as when it is used in the entire stick. The value of the timber of the larger spruces is not very well known; but analogy would lead us to suppose that it cannot be better than that of the Norway spruce.

The Norway spruce has been known for more than 300 years in Britain as a cultivated tree. It grows rapidly—more rapidly, perhaps, than any other of the evergreen coniferæ; and, therefore, though of comparatively little value as a timber-tree, it is one of the very best for shelter; and its dark colour and robust habit make it a fine variety in ornamental plantations. It does not attain nearly the same dimensions in Britain as in its native localities, probably because the climate is too warm for it; for spruces discharge their pale turpentine in large quantities from the fissures of the bark in hot seasons. The more protracted season of growth, and the greater difference between the temperature of the day and the night must have an effect upon it; and, judging from the situations that it prefers on the continent, the summer rains of England cannot be over and above favourable. The almost continual day in the polar countries, while vegetation is active, produces a uniformity of temperature, and a consequent uninterrupted growth day and night; while in countries farther to the south, the vegetable action is, more especially in the early part of the season, when such alternations are most dangerous to it, checked every night and renewed again every morning.

In France, the Norway spruce is called *Le Picéa*, the "pitch" spruce, and yields the Burgundy pitch of commerce. For obtaining the pitch, stripes of the bark are raised up in the spring, and the resinous matter exudes in greater or smaller proportion according to the soil and age of the tree—the quantity being most abundant on rich and fertile soils, and the quality best from full-grown trees. The substance that accumulates on the places deprived of the bark is scraped off from time to time. When a sufficient quantity for that purpose has been obtained, it is melted in boiling water, and strained through thin bags to separate the impurities; and it then forms the fat or light-coloured pitch. That pitch may, however, be blackened by partial charring, or, which is nearly the same thing, by the admixture of smoke. Of course, that which is obtained in dry weather is the best; and the warmer that the weather is the produce is the more abundant. If the barked stripes are narrow, the tree may be made to yield for several years (Duhamel says for twenty); but in the majority of cases the trees perish. Thirty or forty pounds of pitch is about the annual produce of the best trees. An essential oil may be distilled from the resin of the Norway spruce, but it is very inferior to the oil of turpentine, which is obtained by distilling the resin of the silver fir.

In some parts of France the bark of the spruce is used in tanning. In Sweden and Norway it is made into baskets; and canoes are made of the timber, so light that one man may carry his canoe on his shoulders. Those canoes are sewed with cords made of the roots of the tree, so that they have not even a nail of iron in their structure. The long and slender roots are preferred for these cords (which are applied to many purposes in the northern countries), and they rendered flexible by boiling for an hour or two in water mixed with ashes. The young shoots are sometimes used in those countries as part of the winter-food of horses; and there is not much doubt that the common spruce, and probably all the class of the spruces (which are not nearly so austere as the pines) might be made to furnish an ingredient in beer as grateful as that which is obtained from the spruce of America.

Silver Fir.

The silver fir *(pinus picea,* vel *abies pectinata)* is a native of the northern slope of the Alps, and their continuation eastward through the Austrian and Turkish dominions; and appearing, also, in the northern mountains of Asia Minor, and extending into Siberia, where it occurs in considerable numbers between the rivers Obi and Irtisch, and takes a much more northerly situation there, in respect to the whole vegetation, than it does in Europe. Upon the mountains of Caucasus, the silver fir grows at the height of 5400 feet. It is not found in the Scandinavian forests, and hardly in those of the Carpathian mountains. It is very abundant on the north slopes of the Alps, and in the mountains of the centre and east of France. On the Alps it is met with at the height of 4500 feet, and it grows also in the valleys as low as 600. On the Pyrenees it is found 1500 feet higher than on the Alps, being met with at an elevation of 6000 feet.

On some of the mountains of Asia Minor, the silver fir is said to be a magnificent tree, though in Europe it seldom exceeds seventy or eighty feet in height. Though decidedly a spruce in the arrangement of its leaves, the mode of its branching, the texture of its wood, and the colour, though not the quantity, of its turpentine, the silver fir differs in very many of its characters from the Norway spruce. The young leaves are flat, partially formed into two rows on opposite sides of the twig; and hence the name of *pectinata*, or resembling a comb. As they advance in age they become more pointed and flattened; and in that habit there is a resemblance to some of the araucarias. The cone, instead of being pendulous like that of the Norway spruce, is erect, and sessile upon the twig, without any visible peduncle. It is also more cylindrical than that of the spruce; and the membranous bracteæ are persistent, and remain projecting from between the scales. The scales of the cones separate from the axis, and fall along with the ripe seeds. The cone is, indeed, so peculiar that it is decisive of the species; so, indeed, are the leaves, by the two silvery streaks on the under surface, from which it gets its common name of silver fir. The resin of the silver fir, which is obtained in considerable quantity, is known in commerce by the name of Strasburgh turpentine. That turpentine is much more fluid, and also much more pungent, than that obtained from the Norway spruce; and from it the best and most transparent oil of turpentine is obtained. The peasants, in those parts of Switzerland and France where silver firs abound in the forests, collect the turpentine in the summer. It is chiefly the natural exudation of the trees, and found in drops, which are climbed for and taken in ox-horns or tin-plate vessels of a funnel-shape—the collector having another vessel at his girdle, in which he deposits what he obtains by means of the horns.

The silver fir, being a native of warmer and more inland climates, does not grow fast or thrive very well in England; and, except as a variety in ornamental grounds, there is little to recommend it to the notice of the cultivator.

ASIATIC SPRUCES.

The spruces of Asia may be divided into those of the north and those of the south, or rather those of the centre—the former following the line of the mountains of Caucasus and the Altaian ridge into Siberia; and the latter following the Taurus and the mountains of northern Persia, the Hindû Cosh, and the Himalaya into Siberia. Among the former are the Norway spruce and the silver fir, with some changes produced by climate; and there are also some peculiar species.

The chief, if not the only, species peculiar to Asia, north of the table land, is the Daourican spruce (*pinus* vel *abies* Daourica). It is found in the mountains of the country after which it is named. The forests are considerable; and as the country in which they are situated lies beyond the first or most northerly ridge of the mountains, and not far from the great fresh water lake, or sea, of Baikal, storms are frequent, and the soil is better watered, and vegetation more luxuriant, than in those stilly regions nearer the polar sea, where the frost appears to hold the very weather enchained; and the scanty crop of cryptogamous plants vegetates over a soil which is perennially frozen below.

The spruces of central Asia are more peculiar and more important; and some of them are among the most magnificent and beautiful of the whole order.

Pinus orientalis is the one which is found farthest to the west. It occurs in the Taurus and the mountains of the north of Persia; but its range, and the mode of its grouping, have not been satisfactorily ascertained. It is a very peculiar species; the leaves, without any silvery streak, are of a lighter and purer green than the majority of the spruces. They are short, stiff, and four-sided; and they are so diminished toward both ends of the year's growth that the twigs have the appearance of elongated beads, with a portion of the wood naked and leafless between the growths of the successive years. The cones are small; and there is, in the whole habit of the tree, a lightness not common to any of the spruces.

The lancet-leaved pine of China, *pinus lanceolata* (*Cunninghamia lanceolata* of Brown), has more the habit of a spruce than that of any other of the coniferæ. In the fructification there are some peculiarities, which led Brown to erect it into a distinct genus, and to name it after James Cunningham, an eminent botanist of the early part of the eighteenth century. The anthers, or receptacles of pollen, arranged in threes, and the seeds having the same number and arrangement, are the peculiarities by which the fructification is different from that of (we believe, for there are some in which the fructification has not yet been seen,) all the other coniferæ. The leaves are flat, lancet-shaped, and erect; and the cones are round, and have the scales pointed. So

Cunninghamia Lanceolata.

that in these respects there is a resemblance to araucaria; but the tree is not dioecous, like these.

In the hilly parts of China these trees must form extensive forests, as they are said to constitute the principal timber used in building. It may not be improper to quote the account given by Dr. Abel, who accompanied Lord Amherst's embassy to China, of the manner in which it is floated down the rivers to the great towns where it is in demand.

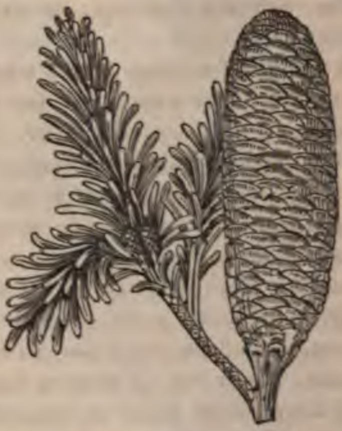
"The rafts of this timber, which are floated down to Canton, are," says Dr. Abel, "very singular objects in the eyes of a stranger; consisting of an indefinite number of small rafts, fastened together, and covered with the dwellings of the managers.

"The smaller rafts are usually ten feet wide, and five feet above the surface of the water. They are joined together by twisted osiers, and extend, as affirmed by Du Halde and others, to more than a mile in length, and are numerous in proportion as the timber-merchant is rich; and they are so constructed that they move as easily as the links of a chain. Four or five men guide them before with poles and oars, and others assist along the sides at equal distances. They live in wooden houses, and sell their dwellings at the different cities where they sell the timber; but sometimes, it is said, they navigate a hundred leagues in transporting it to Pekin." This mode of floating timber has some resemblance to that upon the Rhine, in Europe; but probably the Chinese are the more ingenious conductors.

The spruces of the Himalaya are highly interesting; but the march of science over that country has been too recent and limited for ascertaining perfectly their localities; though it is probable that, alone or mixed with pines, they form a very considerable portion of those thick forests which are described as occurring in the valleys and on the slopes of the mountains, more especially to the north of the summit, where the summers are so warm in proportion to the elevation.

The one that claims the first notice is,

Pinus Spectabilis.



There is hardly, in the whole catalogue of trees, a more beautiful subject than that spruce, or rather that silver fir—for the silver fir is the European tree which it most nearly resembles.

It is not one of the tallest of the tribe; but it attains the height of eighty or ninety feet, with a diameter of three or four feet at the base. The bark is smoother than that of most of the tribe, and it is of a light silvery colour. The leaves are single, flat, about an inch in length, and of a very bright and beautiful green, with a silvery line in the centre. The cones grow singly: they are erect, ovate-cylindrical, about five or six inches long, and of a fine purple colour. So bright is that colour, that a purple paint or dye is said to be made from the extract of the scales. The seeds are very strongly impregnated with resin, which is generally, though not always, an indication of valuable and durable timber.

The whole aspect of the tree is highly interesting, as well for the gracefulness of the shape as for the beauty and contrast of the colours; and if it could be made to bear the climate of England, it would be among the most ornamental of trees. Nor is beauty its only recommendation; for it has claims on account of the goodness of its timber. As our knowledge of the tree is but recent, little is known respecting its growth—whether it be fast or slow—or about the duration of the timber; so that there are not sufficient data for estimating its comparative worth in an economical point of view; but the timber is handsome and compact, and can be applied to purposes for which the spruces are not, in general, very well adapted. The colour, and also the hardness, of the wood, are said to resemble those of the Bermudas cedar (that of which black-lead pencils are generally made); but as it is made use of for handles of tools and stocks of planes, it is most likely stronger than the cedar, and not so easily splintered. From what is stated of it, it appears to be an excellent tree for house-carpentry, more especially for inside work.

Another of the Himalaya spruces is the *pinus dumosa.* It is a more dark and shady tree than the other; not so finely coloured, or in any way so interesting. The dumosa has small cones, and may be considered as holding nearly the same rank among

AMERICAN SPRUCES.

There are many spruces, natives of the pine forests of North America, some of which have more the habit of the Norway spruce, and others more the habit of the silver fir; and, as is the case in Europe, the latter have a more southerly habit, being found in Virginia and also in Mexico, where the pine forests, after a considerable interruption, occur with new characters.

The species which most nearly resemble the Norway spruce are the "white" and the "black," so called from the bark of the latter being darker than that of the former. Both of them have four-sided leaves like the Norway; but they differ from that, as well as from each other, in the cones. The cone of the white spruce is not so long as that of the Norway, and the edges of the scales are entire; the cones of the black are still shorter, and the edges of the scales stand up in a wavy manner. The scales on the cones of both are oval, or roundish, and not rhomboidal, as in the Norway spruce. The third species is called "red" spruce, still from the colour of the bark. The leaves of the red spruce are flat; and the cones are oblong and blunted, with the scales rounded and entire at the margins.

The fourth species, the Hemlock spruce, or Canada spruce, deviates still more from the character of the Norway. The leaves are flat, formed partially into two rows, and (which is very unusual among the coniferæ) they are slightly toothed or serrated in the margins; and the cones are of an oval shape. The spruce used in the manufacture of "spruce beer" is made of an infusion or decoction of the twigs of this species; and from it also is obtained the resin which is known by the name of Canada balsam.

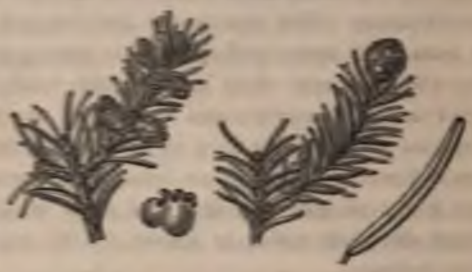
The American spruce which has most the habit of the silver fir is the balm of Gilead fir *(pinus* vel *abies balsamea).* Its leaves very much resemble those of the silver fir, and its cones, like those of that, are erect, and their scales separate with the seeds; but the *bracteæ* between the scales are much shorter. The resin is rather abundant, is known in commerce as Canada balsam, and resembles that of Strasburgh, and answers the same purposes.

The American spruces all yield timber of a white colour, containing little resinous matter in its substance, clean and straight in the grain, and easily worked; but soft, weak, and by no means durable. As objects of British culture, none of them are of any value, except as matters of curiosity, or as varieties in ornamental plantations.

Pinus Fraserii is nothing but a variety of the last-mentioned species.

But the most splendid of all the American spruces in point of dimensions is the yew-leaved pine,

Pinus Taxifolia.



Those figures by no means give an accurate notion of the part of the tree that they may be supposed to represent. The leaves are accurate, and so are the pollen vessels on one of the twigs; but the button on the termination is not the cone, even in its young state; it is simply the bud which is to produce the twig of next year, and which, as appears in the figure, consists of a very close hybernaculum of scales.

The tree had been seen near Nootka Sound, about the 50th degree of north latitude, on the west coast of America; and it was more recently met with by Mr. David Douglas, the enterprising botanical traveller of the rocky mountains, of far larger dimensions, and about ten or twelve degrees farther to the south. It is probably scattered along the west coast of North America, from California, indefinitely, to the north; and from the heights, near the shore, to the Stony Mountains; but there is no evidence of its being found to the eastward of those mountains, or to the south or east of the Gulf of California. It is not found (at least not generally) in close forests, but singly, or in small groups, interspersed with pines of nearly equal dimensions. It has been sometimes named *Douglasii*, after its discoverer, in its southern locality and of its most gigantic size; and though the *taxifŏlia* be a name expressive enough of the form of the leaves, one regrets that the *Douglasii* is not retained; as, if ever discoverer deserved to have a plant called after him, it was Mr. Douglas, who underwent no ordinary share of privation and peril in exploring regions untrodden by the foot of civilized man. Besides, the distinctive epithet *taxifolia* had been applied to the silver fir of Europe, and therefore it was an appropriated name. It is true that *pectinata* is as descriptive of the silver fir; but if the distinction is to be made (and it ought to be made, as one founded upon good and distinct natural characters), the tree in question is not a *pinus* but an *abies;* and *abies taxifolia*, which ought to be the name if it is taxifolia at all, is the very name given to the silver fir.

Majestic as are the spruces of some other parts of the world, the largest of them would seem but a dwarf if placed by the side of that one. A stem, on a base from fifty to sixty feet in circumference, rising in one straight and unbroken cone to the height of from 200 to 250 feet, is something for which one is hardly prepared in the vegetable world. The spruces of other regions serve for masts, and canoes of considerable dimensions may be hollowed out of their stems; but the stem of that one might be carved into a tolerable ship; and, set on end, it would make no contemptible spire for a cathedral, in which apartments and stairs might be cut out, and bells swung.

The spruces of Mexico are found on the table land, and principally toward the east side of it, where the mountains attain the greatest elevation.

One of the most celebrated spruces in Mexico is *pinus religiosa;* so called from its use in religious processions and in the decoration of churches. It grows in great numbers on the elevated parts of Mexico; such as the Peak of Orizaba, Perote, and several other places: and its dark green foliage forms a remarkable, and by no means an unpleasant, contrast with the arid wastes and prickly vegetation of the intervening places. It is a handsome tree; attaining the altitude of at least 100 feet. In its habit it is something intermediate between the spruces and the silver firs; and, indeed, it resembles the balm of Gilead fir of North America more than any other. Its cones are upright, and the leaves pointed.

Pinus hirtella is another spruce of the same regions, having several characters of the former one; only it is of much smaller growth, and, perhaps, ought to be considered as a mountain shrub rather than a tree. It is called hirtella because the branches are beset with hairs. In its height it seldom, if ever, exceeds twelve feet, and its diameter is inconsiderable; so that it is of little value as timber.

In South America, in Africa, or in the countries in the South Sea, there are no spruces, though one large tree is called the New Zealand spruce, and employed by the natives in the manufacture of a sort of beer; but that tree is not a spruce, or one of the *abietinæ* at all; it is a dacrydium, and as such it is usually classed with the *taxinæ*.

SECTION IV.—PINES, PROPERLY SO CALLED.

These are much more numerous in their species, much more widely diffused in their native regions, and form much closer and more extended forests, than the spruces. They are also much more valuable as timber, and for the resinous matter that they yield.

The known species of pines amount to above forty. Of these nine or ten are found in Europe, where they extend from within the arctic circle to the shores and islands of the Mediterranean. About fourteen are natives of Asia, from Siberia to the confines of Hindostan. There are more than fifteen in North America, from Labrador to the peninsula of California; and some species have been discovered upon the mountains in central America; and one in the St. Domingo, and one in the Canary islands. In stating numbers, it is necessary to qualify them by the word "about," because there may be many species yet undiscovered. In Europe that can hardly be the case; but in Asia, from China (indeed from the Chinese sea) to the lake of Aral, and from the Himalaya to the farthest ridge of the Altaian mountains; and in the western parts of North America, as well as in the Andes in the south of that continent, there is much yet to be explored. Only two of the pines have been found on the continent of Africa; there are none in New Holland or Van Dieman's island, or in any of the isles of the South Sea; and there is little probability that future search will find any there.

The pine, once seen in almost any of the numerous species, can hardly be mistaken in any of the others. The leaves, the buds, the cones, the mode of branching, the colour of the bark, and the texture of the timber, amid variations sufficient to distinguish the species, have so much of character in common as that the genus cannot be mistaken.

In their leaves the pines are all evergreens, and, with very few exceptions, these are slender, or thread-shaped. They are not single in any of the species, and they are always, for a certain length at their bases, surrounded by sheaths. With the exception of *pinus variabilis*, which has sometimes two leaves in a sheath, and sometimes three, the number upon any one species is the same,—some have two, others three, others five; but the number is constant. In some, the leaves are short, in others they are long; in some they are rigid, and in others they are flexible; but in none can they be mistaken even for the leaves of the spruces, the cedars, or the larches.

With regard to the latter there can be no mistake, as their leaves are of more delicate colour and texture, and, as is general with deciduous leaves, want the firm epidermis of the evergreens.

In all their varieties of species and situations, the pines may be considered as budding-trees. Having definite annual periods of growth, during which they elongate both in the stem and the branches; forming buds only at the end of those annual growths, one terminal and others surrounding it; and all of them, if not destroyed, producing shoots during the growing season of the following year. Few of the pines grow within the tropics; and those that approach even near to those latitudes are in situations so elevated, as to have the seasons so marked that there is a winter, and in some cases a pretty long winter, of vegetable repose, previous to which the buds are formed; and they repose in their scaly hybernacula till the warm season returns.

The cones vary a good deal in their size, their form, their position, and their numbers at one place of the tree; but they can always be known from the cones of any of their congeners. They have the scales more thickened, more arranged in spirals, and with their apices formed into points or discs. They are sometimes single, sometimes in twos, or threes, or clusters; sometimes they are pendulous, and sometimes erect; but they can always be known from the cones of any other trees.

The branching of the pines, though often, as has been already said, obliterated in very old specimens, is, wherever it appears, quite characteristic. The branches always come off at the end of the annual growths, and, unless where the top bud has been destroyed, and rival side ones have risen in its place, they come off nearly at right angles. The very vigorous branches are generally bent upwards toward their points; but the slender ones are not unfrequently pendulous. The bark is of some shade or other of a brown or cinnamon colour; and, when old, the epidermis and some of the layers under it are scaly and cracked. Both in the bark, and in the wood, the annual layers are decidedly marked, one portion of each being much more dark and resinous than the other; and the difference being the more striking, the colder the climate, the more slow the growth of the tree, and the more regular the seasons.

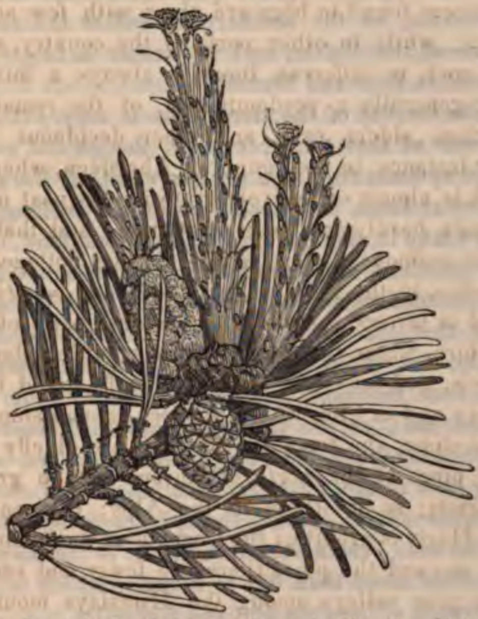
PINES OF EUROPE.

From the irregularity in form of the European continent, and the diversity of its surface in respect of elevation, there is not that accordance of vegetation with latitude which is found in countries wider from sea to sea, and more uniform in their surface. On the lofty mountains in the centre, and even toward the south, the average annual temperature may be found of every degree of cold down to that at which there can be no vegetation, while no part is so near the equator as not to have a considerable difference of seasons. Within the tropics it is the uniformity of the seasons, rather than the high temperature (for there are all temperatures there), that is unfavourable to the growth of those plants that require a cold season of repose. There are two Midsummer-days there, six months apart at the equator, and approaching each other as the tropics are approached; and, whatever period may be between those days, the time of vegetable action, as depending on heat, is made that much longer than if there were only one Midsummer-day. The seasons in those tropical countries are chiefly distinguished as wet and dry. The dry season is a time of repose to the gummy and succulent plants; but it would be a time of activity or of waste to the resinous ones, such as the pines. In the pine districts of Europe, on the other hand, the proper distinctions of seasons are cold and hot; and, therefore, the same pine that flourishes near the arctic circle may flourish on the southern mountains.

Still there is a sort of climatal distribution; some pines belong more exclusively to the north, some to the centre, and some to the south. It is by no means improbable that the rock itself, as well as the soil, the climate, and the seasons, may have very considerable influence in determining the locality of pines. The subject has not been very carefully examined; but it probably will be found that primitive mountains, more especially granitic ones, and those sandy and gravelly soils which are formed of their debris, are the best adapted for pines. The few remains of the vast pine forests that once covered the Scottish mountains are mostly in granitic and gneiss districts. The forests of the eastern Grampians, from the Dee to the Dulnan, are all in a granite country. So are the remains of the forest of Rannoch, the forest in Strathglass, and some minor ones. Nay, there is the same evidence in the bogs: where the country is granitic, the trees found in bogs are pines with few admixtures; while in other parts of the country, where the rock is different, there is always a mixture, and generally a predominance, of the remains of birches, alders, oaks, and other deciduous trees. For instance, in the county of Aberdeen, where the rock is almost exclusively granitic, the peat mosses contain hardly any timber but pine; and that pine is so resinous that it is used by the cottagers for candles, in the same way as the *pinus maritima* is used in Greece; while in the central parts of Forfarshire, where the rock is schistus, alders, larches, hazels, and oaks, are the trees chiefly found in the bogs; and in Fife, where the rock is sand-stone and lime-stone, the trees in the bogs are chiefly oaks. The pines of the north of Europe are on granitic districts; so are those in the Alps; the centre of the Hartz is granitic; the Carpathian mountains are less so, and the pines there are fewer and smaller. The pine valleys among the Himalaya mountains contain much of granitic debris; and if it be true that pines are found upon strata of rocks different from granite, they are generally more mixed with other trees, and their timber is less valuable

The pine most abundant in the north of Europe is the

Scotch Fir.



The Scotch fir *(pinus sylvestris)* is, for distribution, accessibility, and timber, probably the most valuable of the pines, though it is by no means the tree of largest growth. It is called Scotch fir from the vast forests of it that once existed in that country, even in places where there has not for centuries been a tree, and where, if that tree be now planted, it thrives badly. It is called ***sylvestris***, or forest, or wild, because it is the only pine which is found indigenous in the north and west of Europe. It grows abundantly in all the countries north of the Baltic, as far as the seventieth degree of latitude. It occurs again, in great quantities, in Livonia and Lithuania, on the southern, or rather the eastern, shore of the Baltic, and its timber is largely exported at Riga and Memel.

The locality of the Scotch fir is very extensive. Forests of that timber extend, though not without interruptions, from the western coast of Norway to the river Lena, in Siberia—an extent in longitude, if we take in also the mountains of Scotland, of full one hundred and twenty degrees, or one third of the circumference of the parallel. And if we suppose that the parallel is even that of the Arctic circle, that would give a range, from east to west, of full four thousand miles. It may also be mentioned that, as the longitude, eastward, increases, those pines leave the very northerly places, which they hold in the west, and incline toward the Altaian mountains, leaving the spruces farther to the northward. Its northern limit is 70° in Lapland, and little more than 62° in Siberia, which makes a difference of between 500 and 600 miles.

On the Carpathian mountains, it is found at the height of 3000 feet; it is found at nearly double that altitude on the Alps; and on the Pyrenees it extends 1500 feet higher than on the Alps; but it is doubtful whether that which is described as growing there be not a different variety from that of Scotland and Norway. On the Alps and the Pyrenees plants of the Scotch fir are found higher up than the spruces or the silver firs, though *pinus* *uncinata*, on the Pyrenees, and *pinus cembra* on the Alps, grow at greater elevations than the Scotch fir; but neither of these last is found in the extreme north of Europe.

The general character is given in the above cut, in which the amenta of pollen is shown upward, and has half-grown cones downward at the end of a bit of twig of one year's growth. Above that are the young shoots in the early part of the season at which the specimen was taken; with the rudiments of a second inflorescence on their summits. If the twig had been left growing, the anthers would have disappeared, and the cones attained their full size in another year; the rudiments would have advanced to the state in which these appear; and new shoots, with the beginnings of a third fructification, would have come from the buds between those rudiments. There are two leaves in each sheath; they are stiff, and when the tree is healthy they have a tinge of blue or purple, and the twigs on which they are borne are of a cinnamon red, which colour in the bark of the grown tree is a favourable indication of the timber. In favourable situations the Scotch fir will remain sound and vegetating for more than two hundred years; and as it always decays first at the outside, the trees never deceive the woodman by false appearances. There seems in the resinous matter, when not injured by heat, a power of retreating and concentrating itself in the central part of the tree and also toward the roots. This is peculiarly the case when it is immersed in water. Those changes are not the mere decay of alburnum or sap-wood, and the preservation of the hearty wood. For when pines, that have in all probability lain in the earth for more than a thousand years, are taken out more resinous and durable than the full-grown trees that are newly cut down, they are angular, and terminate upward in points. These are often so full of resin, that one can hardly imagine that they could have grown with such a superabundance; but that, as the other parts decayed, their resinous matter (which is not soluble in water, unless there be an alternation of exposure to the air, or the action of heat,) must have retreated, as the ligneous fibres were attacked by the humidity.

It has been attempted to account for the formation of amber in that way, by the ultimate destruction of all the ligneous matter, and the subsequent induration of the resin by the destruction of the greater part of its oil, and the consolidation of the remainder. And if amber were found only in such situations as those on the south of the Baltic, where we are free to suppose that there have been pines, and time, and cold and moisture, enough for such a purpose, there would be at least some plausibility in the hypothesis. But, unfortunately for that hypothesis, amber forms a considerable article of export at Mozambique, on the east coast of Africa, where there is no present indication that can lead us to suppose that pines ever existed; and if we find any production existing independently of any particular combination of circumstances, we are not warranted to conclude that that combination of circumstances is the cause of its existence any where else. Were that the case, if we could suppose a human being to have lived in any climate so severe as that water never was liquid but when melted out of ice over the fire, that person, upon seeing the Atlantic, ought to conclude that it had been melted in kettles.

The pines of central Europe, meaning thereby those of the Carpathian mountains (for it has been mentioned that the Scotch fir is a central and almost a southern pine in the west), are the dwarf pine, *pinus pumilio*, and the mugho pine, *pinus mughus*. The Scotch fir also occurs, but not so high on the mountains as those two species. There is some confusion about those two species; and, by some of those whom we are entitled to regard as the best authorities, both names are applied to the very same species; and as the one is described as being on the Carpathian mountains, and the other both there and on the mountains of Carniola, on the south side of the Danube, they may be the same. In a popular point of view, the fact is of importance only in proportion to the importance of the trees, and in the case under consideration that is not very great. If there are two species, *pumilio* will suit them both, for they are both dwarfs.

Linnæus considered the mugho as a mere variety of the *pinus sylvestris;* but the characters are much too dissimilar for that; though the mistake of the Swedish botanist, in considering the dwarfed specimens of the *sylvestris* in Lapland as *mughus*, has led others to repeat the tale that the Laplanders make their snow-shoes, or skates, of the tough and durable timber of the mugho. Now it is true, that when any tree is dwarfed by cold alone, and not by an unhealthy climate and soil, its timber is remarkably compact; but though it may be very true that the *pinus sylvestris*, when dwarfed by the cold of Lapland, should have very tough and valuable timber, it by no means follows that that should be the quality of the timber of another pine which is a dwarf on all soils and under all climates where it is native.

Having two leaves in each sheath, is almost the only external character in which the mugho pine agrees with the Scotch fir. The leaves are much shorter, the cones are very much smaller; they are sessile in the young state (whereas those of the Scotch fir have peduncles), and they stand right out. The tree is bushy, and seldom exceeds the height of six or seven feet. The timber is very resinous, and when the branches are broken the resin oozes out quite transparent. That resin is known by the name of Hungarian or Carpathian balsam, and the Hungarians call the tree itself *krumholz*. The great forests of the northern parts of Hungary and Transylvania are not of that pine, or, indeed, of any pine at all; they are chiefly of oak, and after that ash. The pines occur on the sub-alpine region, from nearly 4000 to nearly 4600 feet above the level of the sea. According to the accounts, the pines of that part of Europe are of little interest or value. That may be partly accounted for by the extensive beds of limestone and trap that lie along the bases, and cover to a considerable height the slopes of the mountains.

The following list comprises the principal pines of the southern parts of Europe :—

Cluster pine, *pinus pinaster.*
Crooked pine, *pinus uncinata.*
Mountain stone pine, *pinus cembra.*
Pinus pinea, pin à pignons.
Sea pine, *pinus maritima.*
Corsican pine, *pinus laricio.*
Aleppo pine, *pinus Halepensis.*

There are one or two others, but they—and, indeed, some of those in the list—are of very minor importance, being of little value as timber, and also only partially characteristic of the scenery of particular places.

The *cluster pine,* or *pinaster,* is a handsome tree, found in considerable numbers on the coasts in the south of France and in Italy, where, in favourable situations, it attains the height of seventy or eighty feet. In its general habit it bears some resemblance to the Scotch fir, only the leaves are much longer, continue for a greater length of time on the stems, and are of a finer green ; the bark is more smooth, and the tree altogether seems more delicate. The cones are the most striking mark of distinction ; they are produced in bunches round the twigs ; and it is for that reason that the name of cluster pine is applied to it. It grows freely, and even rapidly, in the warmer parts of Britain, and, on that account, it is of some value as an ornamental tree ; but its timber is very inferior to that of the Scotch fir, even when grown upon soils that are not natural to it.

The *crooked pine*, the epithet of which applies to the cones, and not to the stem, has the leaves two and two in a sheath; and they are longer than the leaves of the Scotch fir, but not so long as those of the pinaster. The cones are ovate, and bent to one side; the seeds have seven cotyledons. This pine is found on the Pyrenees, of which mountains it is the only peculiar pine that has been discovered; but, from the difficulty of the passes, there are still some parts of the Pyrenees that have not been explored.

About the *mountain stone pine* of Europe there seems some little confusion, as the name has been applied to *pinus pinea*, which is a two-leaved pine and maritime; while the mountain stone pine grows on the Alps, between France and Italy, and in the Tyrol, and resembles in its cones, and its large and esculent seeds, the stone pine of Siberia, from which it hardly differs, even as a variety—at least, not to a greater extent than can be accounted for by the difference of climate. It is said to grow very slowly, and not to attain more than twenty or twenty-five feet in length. But it grows higher up on the Alps than any other of the pines, or than the larch; so that the slowness of its growth, and the hardiness of its habit, justify the supposition of a relationship, if not an identity, with the stone pine of Siberia.

The *pinus pinea*, on the other hand, is described as rising to the height of between seventy and eighty feet. "It grows," says Desfontaines, "in Italy, in Spain, and in most of the southern departments of

France. I have seen very fine ones along the shores of the sea, between Marseilles and Saint Trapez; but they stood singly. M. de Malesherbes said that he saw one extensive forest of them, on the right bank of the Rhone, in Lower Languedoc." The leaves are only two in each sheath; the cones are large and ovate, about the size of a pine-apple; and the scales are very much thickened. The timber is white, weak, and contains little resin.

The *sea pine* has two leaves in the sheath, long and slender, and rather of a yellowish green. The cones are ovoid-conical, and placed on peduncles. The tree rises to a very considerable height; and as it will thrive very well in dry sands close by the sea-shore, it forms a good shelter, to other vegetation, from sea air, and also from drifting sand, in all situations where it can stand the climate; but as it is a native of the south of France, it is apt to be injured by the severity of northern winters. In Britain or Ireland it would stand better on the shores of the Atlantic than on the opposite coast, or in the interior of the country. The sea pine occurs on all the northern shores of the Mediterranean, and on those of the Adriatic and the bays of Greece. In the latter country it is very abundant, and used as a ship timber, both for spars and planking: and it is reported as being so full of resin that the peasantry use slips of it instead of candles.

The *Corsican pine* grows in the island after which it is named, and is there said to attain an elevation of from 120 to 140 feet; but the timber is light, and not durable. It is found also on the mountains of Barbary. In its foliage it resembles the sea pine, but is of a deeper green, and its general aspect resembles that of the Scotch fir.

The *Aleppo pine*, which is also called the Jerusalem pine, grows on the dry shores of the Mediterranean; and it is common to the three quarters of the world, by which that sea is inclosed. Perhaps it is most abundant in Syria, but it is found also in the south-east of France, though at no great distance from the sea; and also in the mountains of Algiers, and in Tunis. In some of those places it forms small forests; and on the shores of Provence it is called the white pine, from the colour of its resin, which exudes spontaneously from the fissures of the bark, and hardens on the surface. In most situations it is little better than a shrub, and it seldom, if ever, rises to more than twenty or twenty-five feet in height, so that it is of comparatively little value as a timber tree. From the resinous nature of the wood, however, it makes good and ready fuel; and it is altogether curious, as affording an instance of a pine in situations where, from our knowledge of the habits of the more majestic pines of the north, any pine would not be looked for.

As that meagre dwarf is the only pine or fir now met with in Syria, one is a little perplexed about the importance attached to the fir in the Bible; though, perhaps, some other tree was meant, just as the cedar of Lebanon, which was so much celebrated for its durability, may have been some other tree than that with which pleasure-grounds are now ornamented in England. These are not, however, the only instances in which modern observation is at variance with ancient description; and, therefore, one is apt to conclude that there has been a double translation—that the subject has been "done into English," as well as the name.

Before proceeding to take a summary of the pines of the other parts of the world, it may not be amiss to glance back at the distribution of those of Europe—at those only which are in their native and natural localities, of course, because cultivation can change both the locality and the nature of plants. There are certain directions in which the regions of the different pines lie; and these are the very reverse of what we would be led to suppose from the temperature. The Scotch fir *(pinus sylvestris)*, which thrives best within the arctic circle, is, in the western parts of Europe, found as low as latitude 46°, thus having a range in latitude of nearly fifteen hundred miles. About the longitude of Poland, or the middle of Europe, the same pine does not reach farther down than about latitude 54°; so that the range in latitude there is shortened to about one thousand miles; and, still farther to the east, the trees dwindle into shrubs, and are barely found. What analogy the dwarf pines of the Carpathian mountains may have to the pines of the extreme north of Siberia, has not been traced; but there is some resemblance between the long-leaved pines of the south of Europe and those of India, although in Europe they are chiefly found near the shores of the sea, and in India at considerable elevations upon the mountains. It is farther worthy of notice, that the region of the *pinus sylvestris* is chiefly that which is affected by the atmospheric currents from the Atlantic, until we come so far to the southward as that these are turned by the Pyrenees, and the mountains of Cevennes and Cantal.

PINES OF ASIA.

The pines of Asia may be divided into northern and southern ones, in like manner as the spruces. Those in the north are few, and though some have been named as if spruces, it is by no means satisfactorily made out that there is any pine, north of the Altaian mountains, except the Scotch fir and the stone pine. The stone pine is not found in the plains in any part of Europe, as it does not inhabit regions so far to the north as to have pines (with the exception of maritime pines) on the low grounds. In Siberia the case is different; the stone pine is found in the plains, and it extends farther to the north than the Scotch fir. It is the same with the larch; that is in no part of Europe an inhabitant of the plains, unless where it has been planted by art. And it, too, is found so far north, and so dwarfed in Siberia, that it has been considered as different, and had a specific name given to it. That the pines of the south and east of Europe should take the most northerly place in Siberia, while the pine of the north-west of Europe takes a more southerly locality, is worthy of notice. Both the Scotch fir and the stone pine are hardy trees; but it seems that each has its own peculiar kind of hardiness—the Scotch fir against a stormy and variable climate, and the stone pine against long-protracted winters and dry summers. In these respects, the vicinity of the Altaian mountains seems more to resemble Norway, and the countries round the Baltic; and the plain, or northern hills, and slopes toward the rivers of Siberia, more to resemble the summits of the Alps and the Carpathian mountains.

As the localities of the stone-pine in Europe are rather confined, perhaps it may with most accuracy be described as a Siberian tree; and as such the following figure is given.

Pinus Cembra.

The Siberian stone-pine, which is but of low stature in those bleak and elevated parts of Europe in which it is found, is a stately tree in the north of Asia—so much so as to get the name of the Siberian cedar. It is only in the better parts of the country, however, that it is a large tree. In some of the more southerly forests, especially in those near the river Jenessi, it grows to the height of 100 or 120 feet; but it grows slowly, and some of the trees, while in vigorous growth, show 150 to 200 rings of wood, indicating a duration of an equal number of years. Even in the colder situations, toward the north and east, it is dwarfed rather than distorted; and eastward of the Lena, where it is found scattered as far as the shores of the eastern sea, and where it has sometimes been considered as a separate species, and named *pygmæa*, from its diminutive size, it is not distorted.

From the places where it grows, both in Europe and Asia, the stone-pine may be regarded as the most hardy of all the tribe, and it forms strong, hard, and durable timber; but its growth is so very slow that it could not be cultivated to any advantage in the British islands, which are not, at any rate, the description of climate in which it would thrive best.

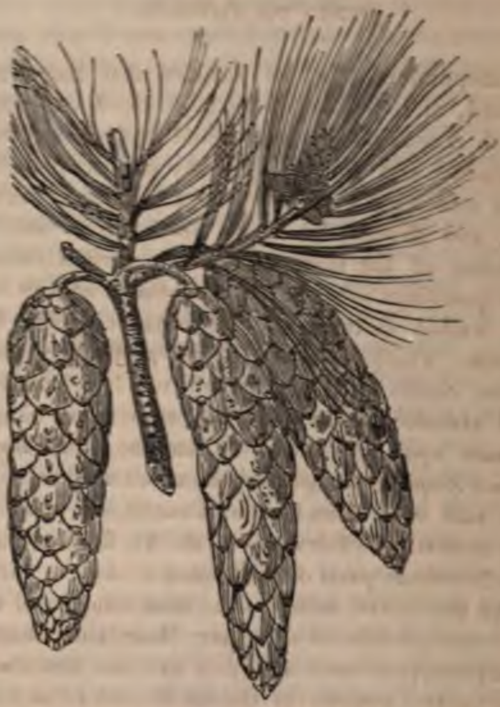
The stone pine has five leaves in each sheath; the cones are oval, with the scales very large and thick at their extremities; and the seeds are large and may be eaten. The cones are highly coloured, but not nearly so much so as those of some of the spruces.

Little is known of the pines of central Asia, from the shores of the Caspian, or rather from the mountains eastward of the lake of Aral, to China; although, from the appearance of the mountains both on the north and south, there is little doubt that the table land, where not too arid for the purpose, is a country of pines.

In the eastern parts of China there is one pine represented as being very abundant. That is, in all probability, the *pinus Sinensis*. It is said to be a two-leaved pine, intermediate in aspect between the Scotch fir and the Corsican pine *(pinus laricio)*. Dr. Abel, who accompanied Lord Amherst on his mission to China, says, "All the groves that I saw in China were of this pine, which appears to be one of the most widely diffused on the continent of China; we met with it through more than ten degrees of north latitude, and six of east longitude." An embassy, passing through such a country as China, is not, however, the very best means by which accurate botanical information can be obtained,—as the members of the embassy would not be allowed, and could not, if permission had been given them, leave the roads to examine the groves; and thus the groves may have been artificial, or formed of different pines.

Two of the most remarkable pines in the Himalaya, are the *longifolia* and *excelsa*. The *longifolia*, which is very properly named from the great length of its leaves, grows lower down upon the Indian side of the mountains of Nipâl, than some of the other pines of the Himalaya. It is a three-leaved pine; the sheaths are much elongated, and the leaves themselves are very long and slender, and hang down gracefully. The branches are in whirls like those of the Scotch fir; and the cones are arranged in the same manner. From the peculiar character of its leaves, the long-leaved pine must be a very graceful tree. In the mountains it grows to the height of 100 feet or more; but in the gardens about Calcutta, where it has been introduced as an ornamental tree, though it bears the heat of the climate, it is of but small size.

Pinus Excelsa.



The *pinus excelsa* has more the habit of the Weymouth pine; but the leaves are longer. They are in fives in each sheath; and the cones are long and pendulous, and have foot-stalks and very large scales, of an ovate form, and not thickened at the points. The excelsa exceeds the longifolia in dimensions; but still it is by no means the tallest of the pines.

PINES OF AMERICA.

Independently of the spruces that have been noticed, and the larches to be noticed afterwards, North America is, in an especial manner, a country of pines; and though, in many places, they have been somewhat wantonly wasted by the axe and by fire, and though the snows break them, and the violence of the thaws and floods carries them in vast quantities into the St. Lawrence, whence they are wafted eastward by the current of the Gulf stream; which, deflected by the projecting land of Nova Scotia, and the island of Newfoundland, and arrested by the polar ice, casts them in great masses upon the shores of Iceland, Jan Mayen, Nova Zembla, and part of the north of Asia; they are still very abundant in Canada, as well as in the countries to the south of the St. Lawrence, and the Northern parts of the United States.

In the central valley of the Mississippi, and upon the eastern side of the Stony Mountains, they are comparatively few; and they are not abundant in the central country to the northward of the great lakes; but they occur again to the westward of the mountains; and some of the largest are found, along with the gigantic spruces, in or near California. In the low country of Louisiana there are few or none; but they again occur with the spruces, on the elevated parts of the table land of Mexico. Some of them are of small dimensions, and found on the sandy tracts near the shores of the sea; some are met with in swamps and morasses, and some that grow in good soil, among or near the mountains, attain a very large size, and are valuable for their timber; though, perhaps, none of them are so durable as the pines of the eastern continent.

Perhaps the species which has the most northerly locality is ***Pinus Banksiana***, the Hudson's Bay pine, or rock pine. It is a two-leaved pine, with the two leaves turned away from each other; and it is remarkable for the crooked form of the cones. The branches are numerous, long, and spreading; the cones are in twos or threes together, very numerous, of a yellowish colour, and more slender than those of the Scotch fir. It is found in sandy places among the rocks, in the dreary and inhospitable regions that border upon the bay after which it is named; and it is also met with as far to the westward as Mackenzie's river. The beavers make a good deal of use of it in their singular architecture; and the beaver-hunters also employ it in the construction of their huts, and for fuel. It is well adapted for the last purpose, as it contains a great deal of turpentine, and gives out a strong heat. It hardly enters, however, into the commerce of the country as pine timber.

Pinus Strobus.—Weymouth Pine.

Perhaps the most handsome and valuable of all the pines on the east side of North America is the Weymouth pine.

The Weymouth pine is, or once was, found in the whole of the elevated ridge, from Canada, as far south as the Carolinas. It is a five-leaved pine with long pendulous cones, something resembling the excelsa of the Himalaya; but the leaves are not so long. It grows to a very considerable height and diameter; and as it grows clean and straight, and is light and elastic, though not very strong timber, it answers for masts. When North America was settled by English colonists, the Weymouth pines were reserved from the havoc that was committed upon the other trees of the forests. A law to that purpose was passed in the 9th of the reign of Elizabeth. The trees are often of splendid dimensions, affording timber to the length of from 80 to 100 feet; and specimens have been cut down of between seven and eight feet in diameter at the base. Sizes like that are, however, rare; but it is by no means uncommon to meet with fine logs that square to between three and four feet. The timber has the advantage of being clean and easy to work; and, although it is not very durable, it is moderate even in that respect.

The Weymouth pine may bear to be considered as a sort of type of a subdivision of the pines. The cones, the bark, and the timber, have some resemblance to those of the spruces; but in most respects the tree is a true pine, although very unlike the *pinus sylvestris*. Though the Weymouth pine is not a native of the very coldest parts of North America, it bears the climate of England, and is, probably, the only pine of the east of America that is worth cultivating for economical purposes.

The American pitch pine *(pinus resinosa)* is another pine which is diffused over a considerable extent in latitude; but it does not reach so far to the south as the Weymouth pine, the state of Pennsylvania being about its southern limit. It is a two-leaved pine, with conical cones growing in threes. The wood is full of resin, but it has not very many qualities by which it can be recommended.

In the central and southern parts of the United States, the pines are inhabitants of the swamps and wastes, and some of them have a great tendency to overrun and spoil lands that are allowed to go out of culture. One of the most annoying in that respect is the frankincense pine *(pinus tæda)* a small long-leaved pine of very slow and not very seemly growth. It covers large tracts in the southern parts of the United States, and where it has once established itself it is extirpated with difficulty, and the land is said to be nearly ruined for other purposes.

The swamp pine *(pinus palustris)* is another of those unseemly and unprofitable members of the tribe. It grows in the marshes, and thus occupies ground that is not very valuable for other purposes. It is a three-leaved pine, with very long leaves, and sub-cylindrical cones, beset with sharp points on the scales. It is found chiefly in the swamps of the central and southern parts of the United States.

The variable pine *(pinus variabilis)*, called also the hedge-hog pine *(pinus echinata)*, from the habit that it has of forming leaves at the knots, and in the fissures of the bark, — is remarkable for having, sometimes, two leaves in a sheath, and sometimes three. The leaves are about an inch and three quarters in length; and the cones are about two inches in length, solitary, pendent, elongated, oval, and having spines on the scales. It grows on the sandy parts of the American coast; and though its appearance is rather ragged, and its size small (its height is about forty feet), it affords better timber than many of the larger and more handsome pines. It is very resinous, and said to be, in strength, rather superior to the Scotch fir. The French once built a 64 gun ship wholly of the pinus variabilis.

The Jersey pine *(pinus inops*—the poor pine) gets its English name from the state of New Jersey, between the mouth of Hudson's river and Delaware bay; and its Latin name from its starved and wretched appearance as compared with most of the other pines. It almost invariably grows crooked; and seldom reaches the height of forty feet. Its leaves are two and two, nearly two inches in length, channelled into a hollow on the one side, and convex on the other. The cones are sessile, pendent, ovoid-cylindrical, about the same length as the leaves; they grow singly or in pairs, and the scales have upon their crowns a projecting scale a little curved. The Jersey pine grows in sandy soils. The timber is reddish and very resinous; but, from the small growth and uncouth shape of the tree, it is not much used. The tree is not, however, without its use; for it furnishes abundance of pitch of very good quality

There are several species of pines in the same elevated parts of Mexico that produce the spruces. These, as might be expected, have more the character of the other American pines than of those of the eastern continent; but as they have a more southerly latitude than even the pines of that continent, they have some resemblance to the pines of the Himalaya—or rather, perhaps, to the Weymouth pines.

Pinus patula is, in fact, not very different in its habits from the Weymouth pine, only it has but three leaves in each sheath.

Pinus Leiophylla is rather peculiar in its habit; it has five very slender leaves, and, in that respect, is something analogous to the Weymouth pine, while in the form and position of its cones it very much resembles the Scotch fir.

Pinus Montezuma may be considered as the American type of the long-leaved pine of Asia, which it very much resembles.

Pinus Teocote is the southern representative of the frankincense pines of the northern parts of America, *rigida* or *tæda*.

In the mountains of St. Domingo, or Hayti, there is a pine *(pinus occidentalis)* which resembles the pines of the American continent, — the palustris, perhaps, more than any other; but the leaves and cones are shorter in the St. Domingo pine.

The only other islands, in the Atlantic, in which there are true pines, are the Canaries, where *pinus Canariensis*, a long-leaved pine, is found in considerable numbers, especially on the Peak of Teneriffe.

It seems to be a general law of the pines, that those of warm latitudes have much longer leaves than those of colder ones. This is found in Europe, in Asia, and in America; and, therefore, we may conclude that is in some way connected with the latitude; and that, in as far as mere length is concerned, all the difference may probably have been produced by difference of latitude alone. Indeed, observation on a single pine-tree, as affected by different degrees of cold, leads to something like the same result; for in a bleak and unfavourable season the leaves do not attain half their usual length; and when the growth of the Pinaster is checked, its leaves are shorter than those of the Scotch fir.

§ V.—Larches.

Though the larches are by no means numerous, they are highly important. Like the rest of the *abietinæ*, they are monœcous; but, unlike the rest, they are deciduous, shedding their leaves in the autumn, and renewing them again in the spring. Deciduous leaves never have the same firm and smooth epidermis as those which stand the winter, and have to bear the frost. In their young state they are not very different; and thus the occasional frosts of early summer nip the young leaves and twigs of evergreens as readily as those of deciduous trees, and even more readily. But in the autumn, when all stems that are not annual ripen their wood, and when the petioles of deciduous leaves separate from the twigs, the action of the evergreen leaves ceases, and their epidermis ripens; nor, however long the leaf may afterwards remain on the tree, does it ever again acquire the same vegetable action that it had in the year of its production. It is a general law of vegetation, that the same part of a plant performs the same function, whatever that function may be, only once—that is, during one of the seasons of growth in the plant. If the organ be one of fructification, it dies, and is cast off as soon as the seeds are matured; and if it be part of the proper structure of the plant, as an individual, when the seasonal action is over, it stands back—retires, as one would say—and a new structure takes its place, and repeats its function. Thus the actually working parts of plants, unless in those that have no seasons of rest, and they, of course, have no marked distinctions of structure, are all annual; and the moment that they have undergone the autumnal ripening, their decay may be said to be begun. Thus the difference in the duration of the timber or the bark of trees is, therefore, nothing more than a difference in the period of decay. The connexion between the wood and the leaves, in this respect, has not been investigated; and, therefore, we did not advert to it in the chapter on vegetable physiology, though it is a subject by no means undeserving of attention. In speaking of the durability of timber, we must not confound the decay that takes place by nature, and while the young tissues of the tree are still growing, with that which takes place in timber that has been felled. The natural decay takes place after a certain number of years only, though the number depends upon many circumstances besides the species of tree; but with a felled tree the case is different. The better sorts of firs, and, above all other trees, the deodara, may be said to be embalmed after death; the latter is, indeed, a perfect mummy, and the method of its preservation is not very different from that which was practised by the Egyptians.

When that is not the nature of the tree, we must suppose that when any trunk is taken at its maximum of timber, the portion next the pith should be on the very verge of decay, just as the portion next the bark is in the act of being formed. Intermediate between these—but how many rings of wood from the pith, and how many from the bark, is a matter of observation—there must be one ring which is the very best wood in the tree—has come to all the maturity to which it can come, and is not yet in the least affected by decay. That should be the centre of permanence, from which decay should proceed both ways; and the determining of it would be a matter of some importance in the economical use of timber.

The old adage, "soon ripe, soon rotten," certainly applies to the individual structures of vegetables; and it is a popular, and, we rather think, a well-founded opinion, that in trees of the same species, and on the same soil, those which expand their leaves last in the spring, and shed them last in the autumn, afford the best timber. We *know* that that is the case with the ash and the beech, and we are inclined to believe that it is general, and that it extends to evergreens as well as to deciduous trees; and it is just what might, in reason, be expected:

the early spring, from its frequent alternations of heat and cold, is the trying season for vegetation; and the structures by which the timber is ultimately elaborated, being repeatedly checked in their formation, cannot, in the nature of things, perform their functions so well as when they meet with no check during the period of their growth.

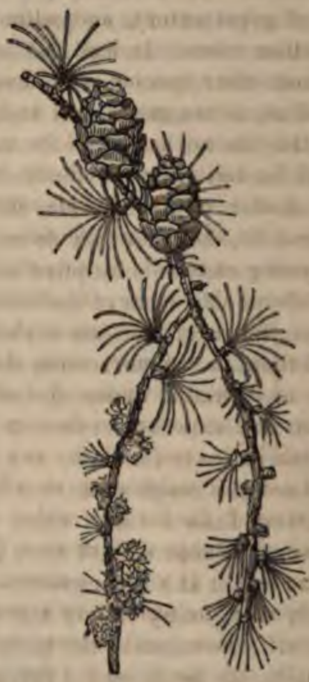
But, in absolute duration, the leaves, the wood, and the bark, do not appear to have any connexion. The yew, which is durable in its timber, and an evergreen in its leaves, has a deciduous bark; and the deciduous larches are more durable timber, both in the standing and the felled state, than the evergreen firs; but, like the firs, they do not form buds in the bark, and cannot be multiplied but by seeds.

When uninjured, the stem of the larch is a perfect cone, tapering regularly from the surface of the ground to the vertex, which is very slender. The branches are small, rather drooping, and the outline of the trunk is but little interrupted at their insertions. The leaves are in fasciculi, or bundles; and as they have not the tough epidermis of the pines and spruces, they have a much softer appearance. That appearance is rendered still more agreeable to the eye, by the bright and lively green, which is very different from the gloomy tint of the spruces and northern pines. The cones of the larches are small and oval, and stand erect upon the twigs.

There are three principal species of larch—the white, the red, and the black; the first is a native of Europe, of the north of Asia (though there it is said to vary in habit), and probably also of the

Himalaya, and other central mountains of Asia; and the second and third are both natives of North America.

European Larch.



Whether we regard it in its native mountains, or as a tree produced by artificial culture, the larch *(pinus larix)* is one of the most important forest trees in Europe. It grows in almost any situation

—grows rapidly—is durable timber, even when young, and there are few trees better adapted for battling with the winds in stormy places.

Its native habitat is the Alps, and their continuation eastward, from the banks of the Rhone eastward into Turkey. In many places they compose forests of great extent, and without much admixture of other trees. Indeed, as larches grow faster than most other species, and thus soon overtop them, and as no tree grows well under the shade of a larch, they do not suit well for mixed plantations. It will be easily seen that the larch cannot be so good a shelter tree as the pine or the spruce; and that, therefore, though much more valuable in itself, in its young state it is by no means so eligible as a nurse. Being deciduous, it affords no shelter during winter, the very time when shelter is most wanted; and then, in summer, when the deciduous trees, which are nursed under the shade of the coniferæ, want free exposure to the sun and air, the larch puts forth its leaves, and the sun and air are excluded. Larch, if cultivated at all, therefore, must be cultivated for its own sake; and for all country purposes, except that of fuel, few trees are more advantageous. It grows on almost any soil—if not absolutely arid, or absolutely a swamp—where other trees will grow, and where they will not, more especially on bleak and lofty places much exposed to the weather. In many situations of that kind in Scotland, where a few larches have been spotted in among Scotch firs for the sake of variety, the larches have made considerable progress, while the firs have made hardly any. That is especially the case on places where the prevailing wind has to sweep over a long extent of cold and bleak surface.

The whole form and structure of the larch fit it well for resisting storms, and existing in countries where, during the winter, there are heavy falls of snow. The stem has more tenacity than the stems of the firs, and it is much more flexible; the branches are also slender and flexible, and the tree is leafless. Accordingly, when the wind blows hard, it gives way, and recovers again between the gusts; and thus the force with which the wind tends to snap a larch, is reduced to a fraction of that which a wind of equal velocity would have on a stiff tree. The same flexibility prevents larches from being so easily uprooted by the wind as stiffer trees, while their being without leaves conduces to the same effect, and also prevents them from being loaded by heavy snows, which are often very destructive to pines. On Christmas day, 1803, a violent gale, which, of course, came in gusts among the hills, literally ploughed avenues in some of the forests of half-grown pines, while a few larches that were mixed with them were not injured.

If the wind blow strongly and constantly, or very frequently from the same quarter, larches are apt to take a permanent bend; and as they continue to grow very well afterwards, they may be kept bent while growing, for the sake of bent timber, which must be much more strong and durable when even partially the production of nature, than when wholly made by art. However the process may be conducted, the structure of the timber must be injured, and it is always rendered unequal by the stretching of the convex side, and the crushing of the concave; and, when timber has been bent artificially, sa turation with moisture always has a tendency to alter its shape.

The larch is a stately tree, there being specimens in Britain more than one hundred feet in height, with their growth unabated. That is but a trifle, however, in comparison with what is stated respecting the trees of former days. "*Fuit autem,*" says Pliny, "*trabs è Larice longa pedes centum et viginti, bipedali crassitudine equalis.*" There is no rule for deducing one dimension, even of a tree so uniform in its habit as the larch, from another; but the larch is always a slender tree, and two feet diameter is, in the south, about the estimate for 120 feet in height. So that, even supposing the beam mentioned by Pliny not to have been squared, but the trunk up to the branches, of a tree from a close forest, in which the part up to the branches is nearly cylindrical, Pliny's, or rather Tiberius's, tree must have been 240 feet high, which fully rivals, in height, the newly discovered pines of Western America. Pliny was a "story-teller"—that is, like our book-makers (only with probably a little more knowledge of his subjects), he repeated the stories of other people; and, if we were to judge from what is now seen in the Alps, we should question his accuracy. But, in botany, it will not do to infer what has been from what is, otherwise we should have the old story, of the accumulation of trees by the flood, repeated at almost every bog in Ireland and Scotland—nay, repeated as to the site of London itself, for that eastward is full of great trees; we should have it denied that there ever were magnificent forests in those parts of North America where *pinus tæda* now cumbers and contaminates the soil; nay, though it be but as of yesterday, we should have the colonists of Parramatta mightily denying that their "wattle brush" was once a forest of eucalyptus.

We find, in modern times, that the destruction of pine forests has been attended with an increase of dryness, and consequently of temperature; and thence we are entitled to conclude, that cold and humidity are, under the proper circumstances of soil, latitude, elevation, and exposure, favourable to the growth of those trees. Now, about the same period when the large beam of larch is mentioned, it is also mentioned that the Tiber at Rome was frozen over in winter; and that, in the Valley of the Danube, wine was divided to the Roman soldiers with the hatchet. All the accounts also concur in stating that, at that time, Britain and Ireland, and, indeed, the whole north of Europe, so far as known, were covered with forests. Circumstances, that operated so much to produce an abundance of trees, must have tended equally to size in the individuals; and, therefore, though a larch of eighty or a hundred feet in height, be now reckoned a great tree, one of three times that altitude may have been found during the era of forests.

In Switzerland, and along the whole line of their growth, larches supply the principal timber for domestic purposes, more especially for building. For that purpose the timber is admirably adapted, as it is not apt to champ or split by alternations of heat and moisture, and it is remarkably durable. The Swiss cottages are constructed of beams of larch cleft in the middle, and piled upon each other without cement; and the roofs are covered with shingles of the same timber. Those simple structures last for ages; and they are, perhaps, the most durable cottages in any part of the world. Considering the alternations of temperature, and especially the length of time that one of these lasts (for long exposure to heat or cold increases the effect of the opposite extreme when it comes), they certainly last longer than any other wooden houses; and longer, also, than the common brick buildings of England. One advantage of the timber of larch is, that there is comparatively little difference between the old layers of wood and the young. If pine or oak is to be applied to any purpose where duration is important, six or seven layers, at the outside, must be removed as sap-wood; and, in a tree of seventy-two years old, that, reckoning mere length of time, would be one-twelfth of the whole. But that is not the proper mode of estimating. If the growth of the tree be uniform, the wood made in any period will be as the differences of the squares. Thus, in an oak of seventy-two years old, all the wood made after sixty-six years will be sap. Now, throwing out the common factor 6, the hearty wood will be to the whole as the square of 11 to the square of 12—that is, as 121 to 144. The difference of these, 23, is very nearly one-sixth of 144, the whole quantity; and, as the wood sometimes continues seven years as sap, one-sixth of the whole may be taken as the average quantity of sap-wood in a good oak tree; and all saplings and branches not exceeding seven years of age will be of no value, and those at double that age of but little. For, whatever number of years an oak stands in a growing state (and if the sap-wood ripen after that the heart rots), one-sixth of those years may always be considered as lost, if the age is seventy-two. If the tree is younger, the quantity of sap-wood will be greater in proportion. Thus, in a tree thirty years old, it will be as 24^2 to 30^2, that is, as 4^2 to 5^2; or as 16 to 25. The difference of these is 9, which is more than one-third. If the tree were 20, which is about the age at which coppices are cut for bark, the sap-wood would be about one-half. It is true that the value of oak bark, in the tanning of leather, compensates, in some degree, for the want of value in the timber. But larch bark is also useful in tanning; and though it does not contain so much tannin, weight for weight, the additional quantity obtainable, and obtainable from ground upon which oak coppice could not be grown, would render it more economical than the other. At all events, it would improve the quality of the leather; for it is well known that leather tanned slowly, in weak solutions, is much more pliable and durable than that which is forced by concentrated tan; in the latter case, more especially if the skins are thick, the outside consolidates, and the operation never effectually reaches the centre.

There is, perhaps, no timber that bears to be alternately wet and dry better than the larch. Hop-poles, made of the common deciduous timbers of England, rot at the surface in few years, while the vine-props in the south, which are larch, last for generations; and M. Boissel Monville, who had paid particular attention to the subject, was assured, by some of the proprietors of vineyards, that their fathers were ignorant of the time at which those larch props were put down. In the same country, props of spruce do not last, at the utmost, above ten years. That the branches are as durable as stems of the same age, or even more durable, is another advantage of the larch. Indeed, there is no doubt that the general use of larch poles would be a very great improvement in the hop-gardens of England; and it is equally true that abundance of larches for that purpose might be raised upon lands that are, in their present condition, good for nothing; and that thus an additional breadth of land might be brought under tillage with advantage to all parties. But customs and laws, introduced at times and by persons little famed for general knowledge, sometimes alike retard the improvement of the country, and that of its inhabitants.

For all out-of-door works, and, indeed, all common purposes, where a great deal of strain has to be borne, the larch is an excellent timber, and stands tortion probably better even than oak. When larch does snap, it snaps *en masse;* but before it does that, it will bear a twist that would reduce the best deal to fibres. It is, therefore, an excellent timber for axles and capstans, only it has the disadvantage of not forming good moving geer, on account of the clammy quality which it always retains. When it can be procured of the proper shape—and we have mentioned that shape can be easily given to it—it forms very good timbers for vessels, and is excellent for planking and decks, as it does not tear up with scrubbing; and is, perhaps, more difficult to splinter than straight-grained oak. The very same qualities, however, that constitute its value, make it difficult to work. To plane, or even to chip it, costs much more labour than the same operation on fir; and, on that account, it is not a favourite with the workmen, among whom durability is never much esteemed.

There are few parts of Britain in which the larch might not be grown to advantage; but the locality where it would be most profitable is the south, where the Scotch fir does not succeed so well, or furnish so good timber, as in the colder climate of the north. Ireland, in particular, which, first by wanton destruction, and subsequently by neglect, more culpable because occurring in times of more knowledge, has been denuded of its timber, might be much improved by larch plantations. That the larch is the tree which grows nearest the glaciers is a proof that it is the best fitted for a changeable climate; for it is to the daily alternations of heat and cold that these masses of ice are owing, as they never occur on those mountains where the changes from the warm season to the cold, and from the cold to the warm, are short and decided. The region of larches is the region of glaciers.

Another recommendation of larch trees, for exposed situations, is that they are more "instinct with life" than the spruces or the firs, or, indeed, almost any other trees. The larches in the Alps are often shattered by the lightning, torn by the winds, and broken by descending stones and avalanches of snow. When firs or spruces are subjected to those casualties, the water penetrates the wood (which is more split at the fractures), and the tree soon rots internally, and perishes; but in the Alps, it is by no means uncommon to see mutilated fragments of larches growing vigorously, where a fragment of no other tree could exist. Even when it has ceased to vegetate, the larch resists decomposition for a very long time. When the branches are all withered, and so total a separation has taken place between the wood and the bark as that the latter may be pulled off in large pieces by the hand, the timber does not show the least symptom of decay in any part of its structure. Thus, while the larch is much sooner serviceable than many other trees, it may be left till the full maximum of timber in the individual is obtained; or it may be cut at any age, according to the purpose for which it is wanted.

The indestructibility of larch by fire has been exaggerated. No doubt, it is much less easily set on fire than many other species of wood; because it continues longer to give out humidity, and thus preserves a cold surface by evaporation; but, when it is once kindled, it gives out a strong heat, and is good fuel.

The resin of the larch is known in commerce as Venice turpentine; and it is obtained from the trees twice in the year—in May and in September. In order to obtain it, a hole is bored in the south side of the trunk, between three and four feet from the ground, and the deeper the hole is bored, of course the more turpentine is obtained. A spout or gutter is placed in the hole, with a vessel below to receive what flows out. The country people collect the produce morning and evening; and when the holes have ceased to be productive they are closed with plugs. A good tree will furnish between seven and eight pounds yearly, for the space of forty or fifty years. The resin is purified by passing it through hair cloths; and the essential oil may be separated from the resin by distillation; but it is very inferior both in pungency and value to the true oil of turpentine obtained from the silver fir, or from any of the pines that furnish it. Besides the Venice turpentine which is thus obtained by boring the trees, there is an efflorescence on the leaves in the early part of the year, which is called larch manna, or Briançon manna, and is reputed to have at least some of the medicinal qualities of that obtained from the mannæ ash *(fraxinus rotundifolia)* in Calabria.

Taking it altogether, the larch is, next to the Scotch fir—and preferable to that in many situations—the member of the abietinæ most eminently deserving the attention of the British planter.

Siberian Larch.

It is probable that the larch found in Siberia *(pinus Siberica)* is the same as that of the Alps, only changed, as one might naturally conclude, by the difference of climate and seasons. The length of the Siberian winter, and the uniform weather of the summer, must give very different characters to all the changeable properties of the tree, from those that it exhibits on the southern Alps and along the mountains of Dalmatia and Albania. The larch is named as among the Alpine trees of the southern mountains of Asia, and also in Japan and China; and it is by no means improbable that it is scattered all over the mountains that connect the Altaian ridge with the Himalaya; but the accounts are a little vague. "The larch" and "another larch," are mentioned by some of the tourists in the Himalaya; but it is probable that by the "other larch," is meant the deodara, which has some of the habits of the larch; and, perhaps, "the larch" may be the same tree on a different soil. The Siberian larch is of much smaller dimensions, and has the cones much more minute than the larch on the Alps.

American Larches.

The two American larches are both natives of the northern parts of that country. One of these is the red larch *(microcarpa)* and the other the black larch *(pendula)*. Neither of these is very important, as, although they resemble, in many respects, the white larch of Europe, their timber is far inferior. The red larch grows to a larger size than the European larches of the present day, as might be expected in a country still much more in the forest state. The leaves, like those of the other species, are deciduous; but in their colour they have a tinge of blue, and are thus intermediate between the larches and the firs. The cones are round, and not bigger than the point of the little finger. The scales are few, and they are reflected backwards at the margins. In the black larch, the cones are larger and longer, and the margins of the scales are turned inwards. The branches also droop more than in any of the other larches, though in all the species, the branches, and more especially the twigs when they are loaded with cones, are generally a little pendulous.

The black larch, which is the "*Hack matak*," of the Americans, is a swamp larch; and in grounds of that description it is said to thrive much better than the European larch, and even to produce better timber.

§ VI.—CEDARS.

Though there are, in many parts of the world, trees which are called cedars, and though the timber of several species is known in commerce by the name of cedar, yet there are only two species of cedars properly called, and neither of them is known in the European markets as a timber tree. These two species are, the cedar of Lebanon *(pinus cedrus)*, and the cedar of India *(pinus deodara)*. Their appearance partakes both of that of the pines and that of the larches; but still sufficiently different to have a distinct popular character—in some sort common to the two species, but yet so varied in each, that there is no danger of mistaking the one for the other.

They are monœcous, and the leaves are evergreen, like those of the pines, but they want the blueish tint by which the pines are distinguished; and the leaves are smaller, and have not so much gloss as those of the pines of the north. Like the larches, they have a bundle, or fasciculus, of leaves in each sheath; and the cones stand firm and upright upon the twigs. They are both trees of robust habit and majestic appearance; and though they are not the largest of the *abietinæ*, there is an air of grandeur and strength about them superior to what is found in any other of the coniferæ, or, indeed, in any other trees. That character runs through the whole of their structure — the stem, the setting on of the branches, the bark, the formation of the masses of leaves, the cones, and the colour. The stem has a peculiarly firm appearance; and the branches, instead of having the aspect of appendages, as they have in many of the other coniferæ, especially the larches, set off as if they were parts of the stem. Their lateral expansion is very great; and the leafy mass of each droops a little toward its circumference, so that the branch, if a large one, has a slightly conchoidal form, with the convexity upwards. The leaves, which are thickly set upon the whole branch, are on the upper side, and they are so close together that very little light can pass between them. Those circumstances produce depths of shadow, and, consequently, varieties and contrasts in light and shade, much more grand and effective than are met with in any other tree; and one feels, on looking at a fine cedar, as compared with even the finest tree of varied hues, the same sensation of sublimity that one feels on contrasting the solemn and substantial majesty of a statue with the gay tints of a picture. The predominant feeling that one has upon such occasions is that of superior duration. The contrast of different tints is a contrast of surfaces only; and, therefore, the feeling that it produces wants the element of duration, without which no feeling can be said to be truly sublime. The contrast of light and shade in the same tint of colour is, on the other hand, inseparable from a feeling of solidity and duration; and it is not possible to look upon a cedar without having the association that it is a lasting tree.

There are associations, too, connected with the cedars, more sublime in their characters than those connected with any other trees. The constant allusions made by the bards of Israel to the cedar, as the emblem of prosperity, majesty, strength, and duration; and the glowing descriptions of the temples and palaces of King Solomon, are better calculated for captivating the fancy, and impressing the memory, than any thing that is elsewhere said about cedars, or any other trees. The loftiness and grandeur, there ascribed to the cedars, give loftiness to the mountains themselves; and Lebanon owes much of that super-eminence that one feels disposed to give it, above other mountains, to the trees with which it is, or has been, clothed. In both their species, and in all their localities, the cedars are inhabitants of the mountains—of the lofty parts of the mountains near the perpetual snows; and though, in culture, one of them at least, if not both, thrives very well in low situations, they never are, in their native state, found in the plains. There is always, therefore, the idea of mountains associated with that of cedars; and if Lebanus draws sublimity from the one species, the other (which, in fact, needs it less) derives sublimity from the Himalaya. But even there, though the cedar has not had the same advantages, in point of historical celebrity, as the cedar of western Asia, and though it has been but recently known to Europeans, whose first visits, and whose continued intercourse for a long time with India, had certainly other, and very different, objects from the study of natural history, it is held as a sacred tree by the natives—*deodara* meaning the tree of *Siva*, or *Deva*, who is one of the most important divinities in the Hindû mythology. As "the tree of the gods," the deodara is planted near the Indian temples, and comes in for a share of the worship. That it should be sacred, in a country where the attributes of divinity are imputed to a stone or post, smeared over with red paint, proves little; but the fact of selecting that tree as a species, in preference to other trees, even to the pinus spectabilis, the colours of which are so beautiful, shows that there is a grandeur in the air of the cedars which nothing can conceal; but which arrests the attention of all nations where the trees are found.

It is highly probable that both species of cedar could be cultivated easily and with much advantage in England. They both grow near the snow. The cedar of Lebanon is higher upon Taurus than any of the firs; and though the habits of the deodara are not so well known, one would be disposed to infer, from the external similarity of the two trees, and the more resinous and durable timber of the deodara, that that may prove to be the more hardy tree of the two. It is ascertained that some places where it grows have much of the character of Europe in their vegetation; and from the altitude at which it grows vigorously, among that vegetation, its climate must answer to a European latitude fully as far north as that even of the northern division of Britain.

The cedar of Lebanon has been known in Britain as a cultivated tree for at least one hundred and fifty years; wherever it has been planted and allowed to remain, it is one of the most ornamental; and there has been no instance of its decay or death which cannot, to a considerable extent at least, be attributed to casualties. It may be, that part of the reason why cedars have been cultivated in so few places is the supposed slowness of their growth. That, however, as applied to the whole duration of the tree, up to the time of its being a majestic timber tree, appears to be a mere prejudice. No doubt the cedar of Lebanon, and that appears to be the case also with the deodara, grows slowly for the first eight or ten years; but that is the case with most of the good timber trees, and nearly with all of those that stand for ages. In its subsequent vegetation the cedar makes amends for the tardy growth in its youth; and Du Hamel states that it appeared from actual measurement, that the increase of diameter in a year was about seven-tenths of an inch. Nor is there any reason to doubt the statement; for, in a section of a branch now before us, some of the annual rings measure one third of an inch, which, if the growth had been equally free on all sides, would have given nearly the same annual increase. The section alluded to was, however, taken from the branch near the forking of the tree; and as, from the spreading habit, the leaves, and consequently the vegetable action, are chiefly toward the outside, the annual rings, at the place nearest the adjoining stem, are remarkably thin—some of them less than one-fiftieth part of an inch. In the same section there are remarkable differences in the thickness of the rings, as well throughout their whole circumferences as toward the differently exposed sides. At the centre they are all very thin, and they are comparatively uniform throughout their whole circumference; while twice, in the course of the growth, they are so expanded on the one side, and so perfectly evanescent on the other, that they have the appearance of lunettes inclosed in the surrounding rings. The formation of wood, in the cedar, seems, indeed, to be remarkably susceptible, though the causes that affect it have not been studied; for, in the section alluded to, while the growths of eight years on the one side make an increase of nearly an inch, the same growths on the other do not altogether much exceed the thickness of a sheet of paper. It is remarkable, too, that with these fluctuations of growth in the wood (and there are many partial ones at parts of the circumference —some of them, for about an inch in the circumference, having the thickness of twenty, either within or without it), the bark should be of almost exactly the same thickness round the whole circumference. In various other sections of cedar of Lebanon that we have examined, there are indications of the same susceptibility of change in the productiveness of wood; and we may add, that sometimes an extraordinary season occurs, in which, by a great effort, a uniform ring, as thick as the thickest parts of the variable ones, is produced round the whole stem. Nor is it a little remarkable, that those extraordinary growths appear to be of more compact and firm timber than even the thin parts of the unequal ones; which, in so far, negatives the common opinion that firm timber is connected with slowness of growth.

If it were possible to compare a good meteorological journal, for the period of its growth, with the natural kalendar displayed in the section of the cedar, it is probable that some important conclusions, relative to the physiology of plants, or, at all events, to the growth of timber, might be drawn from it. In addition to that, however, it would be necessary to attend to the development of the tree; because, so far as our observation has extended, a great production of leaves is invariably attended with a correspondingly great production of timber, and it is not impossible that those crescents of enlarged timber that we have mentioned are connected with corresponding developments of branches over those particular parts of the stem at which they are found, just in the same manner as the very thin rings occur immediately above the insertion of a branch.

The hardiness of the cedar of Lebanon, as a growing tree, is established, not only by the fact of the great elevation at which it is found upon its native mountains, and by that of the tree not perishing of old age in this country, but also by its being less affected by the variable weather of the spring in England than the pines of more northern countries. Those of Canada, and even of Labrador, have had their shoots blighted by frosts which have not in the least affected the cedar of Lebanon.

The cedar is not very particular as to soil, but it seems to like humidity in the earth, in the atmosphere, or in both. The decay of the cedars in the Chelsea gardens, after the adjoining pond had been filled up, is a proof that the trees love a humid soil, though the casualty there arose from a change of the quantity of moisture at the root, to which the tree had long been accustomed. The preference of a humid air is proved by the fact that the cedars are found so near the snow, from which there is, of course, a continual evaporation during the season of vegetable action.

All those circumstances, and several others that might be mentioned, point out the cedar of Lebanon as peculiarly adapted for ornamental planting in Britain; and as it grows as fast to a large tree as the oak, stands as long or longer, is green all the year round, and therefore a shelter to the land, at the same time that it is the most ornamental of all large growing trees, it is somewhat singular that the planting of it has not become more general; but that, at the very centre and focus of arboriculture, as it were, a stately cedar should still be a sort of sight people go to as to a rarity; and that there should hardly be any such thing as a plantation of young cedars. If planters of trees attended only to the value of timber, in respect of durability, this neglect of the cedar might admit of some sort of explanation; but when we consider that, of the trees which are planted more especially for ornamental purposes, very many are hardly fit for any purpose, how temporary soever, the preference given to Dutch elms, and poplars, and deciduous rubbish of that description, is little short of marvel. For half the year those trees are leafless—when in leaf they are not handsome, and certainly not majestic—they begin to decay at a very early period, and the timber is weak, perishing, and, in the elm, so ugly as not to be applicable to any decent purpose. The timber of the cedar is of a good colour and a most agreeable odour, works well, and is so close in the grain that the following cut of the cone and leaves of the tree is engraved on the wood. Unless care be taken in the drying of it, the wood is certainly very easily split, and is liable to split spontaneously; but, if the management of it were understood, which at present it is not (for cedar timber is hardly known in carpentry), it is probable that it would last as long, and it would certainly be much more handsome, than many of the timbers used for domestic purposes, more especially for the internal boarding and decoration of houses. One quality fits it peculiarly for the latter purpose, namely, that it stands the tool remarkably well, and, therefore, could be carved neatly at a small expense.

It is probable that the cedar has been neglected in consequence of the exaggerated, or misunderstood, accounts of its timber, taken from the ancients, and retained in the books up almost to the present day; and one who is not aware how little connexion there often is between compiling a book and observing, or even understanding, any thing about the subject of that book, would be apt to wonder why a tree, the properties of whose timber were, at every successive publication, stated to be very wonderful—so vastly superior to those of all other trees—should have been grown for a century and a half, in England, without the truth of the published statements being once brought to the test.

Though they have been often repeated, it may not be amiss, were it only for the purpose of warning, to repeat one or two of the statements. The delightful old Evelyn, the adorer of forest trees, and the abjurgator of potatoes, thus writes in his Sylva :—" It (the cedar of Lebanon) resists putrefaction, destroys noxious insects, continues a thousand or two years sound, yields an oil famous for preserving books and writings, purifies the air by its effluvia, inspires worshippers with a solemn awe when used in wainscotting churches; in the temple of Apollo at Utica was found timber 2000 years old; at Saguntum in Spain, a beam in an oratory, consecrated to Diana, was brought from Zante, two centuries before the destruction of Troy; Sesostris built a vessel of cedar of 280 cubits."

The resisting of putrefaction, the purification of the air, and the inspiring of devotion when used in the wainscotting of churches, are of course purely fabulous, though, as we have said, a sentiment of sublimity is certainly inspired by the aspect of the growing tree; and the oil, and the destruction of insects, are at best questionable; the beam at Saguntum is of no determinate age, as the epoch of the destruction of Troy is not settled, nor is it clearly made out that there ever was such a city to be destroyed. As for the building of a vessel 280 cubits long, that cannot be brought as evidence of the durability of the timber, even though the fact were made out that the said timber had actually been cedar of Lebanon; for we have, in this country, and of late years, very expensive proofs, in the progress of the dry rot, that, if the timber is not properly selected, ships last never a day the longer for being big. It is probable, however, that the beams spoken of, and, perhaps, also the vessel of Sesostris, were not of cedar at all, but of the evergreen cypress, which is much more abundant in the Levant than the cedar; or, if of cedar at all, that they may have been of the deodara, which, though we have no evidence of the fact, *may* have grown upon the mountains of Western Asia, before they were parched into their present arid state.

Whether the cedar, made use of by king Solomon, was our cedar of Lebanon, or cypress, or deodara, or some other tree, is not known, and cannot now be determined. Hunter, in his edition of Evelyn, says, "Solomon's fourscore thousand hewers must have thinned considerably the forest of Libanus. Few now remain. Rauwolf, in 1575, said, 'though this mountain had, in former ages, been quite covered over with cedars, yet so decreased were they, that no more than twenty-four could I tell, and two others, whose branches were quite decayed. I could find no young ones.' Mandrell, in 1696, could reckon only sixteen; 'I measured one, twelve yards six inches in girt, and thirty-seven yards in the spread of its boughs. The few cedars remaining are preserved with religious strictness. On the day of the transfiguration the Patriarch repairs in procession to these trees, and performs a feast called the feast of cedars.'"

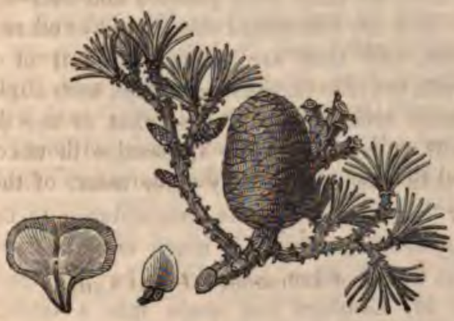
As those travellers do not tell us by means of what data they ascertained that a mountain, having twenty-four old cedars on its top, was once "quite covered over with cedars," it would be somewhat dangerous to speak upon the subject; and the danger is increased by the fact, that though the travellers could find no young trees, one traveller found more old ones than his predecessor. Mandrell found sixteen, one hundred and twenty years after Rauwolf had found twenty-four; and, at the end of about another century, Labillardière found about a hundred, of which seven were much older and larger in their dimensions than the others; the largest about the same diameter as that mentioned by Mandrell. We are not to suppose that the trees, seen by these travellers, were the remains of a forest that had existed at a period even half so remote as that of king Solomon. From the time that he is said to have thinned the cedars, with his levy of thirty thousand men, cutting down by ten thousands in monthly turns, to that at which the earliest of the travellers alluded to visited Libanus, a period of 2580 years intervened; and, though the axes of the king of Judah had never touched a tree, we are bound to believe that the axe of time would have levelled, and the corruption of time changed to dust and gases, any forest in one third of that period. It may be that the change to a dryer climate, and, as is the case with increasing drought in all warm climates, to a climate more impregnated with those salts that are unfavourable to vegetation, may have reduced the number of cedars, as compared to what it was in ancient times. But there is not a shadow of evidence that Lebanon was ever covered with cedars (whatever it might have been with cypresses) upon the lower slopes, or even beyond the limit of great cold on the summit; and as the cedars, on the mountains further to the north, are found only or chiefly on the summits, and are most abundant in places where the air is most humid, what has been stated as probable of Lebanon receives very considerable corroboration from these.

Of the durability of the timber, as found in the Levant, we have no modern evidence, and the ancient evidence does not apply. But, from the trials that have been made in Europe, the timber cannot be very durable, certainly not so durable as larch or pine, and, probably, not so much so as spruce. The wood contains little or no turpentine, has little or no lateral cohesion, water soaks freely into it; and thus it has no quality by which it can resist the changes of the weather, or even the common action of the atmosphere. Though its colour is different, being a light reddish brown, with the rings distinctly marked, it has a considerable resemblance to the knots that are left in the Norfolk Island pine; and it resembles these in their very worst quality—that of champing as soon as it dries.

The specimen that we have given upon the vignette to this sketch of the coniferæ, is comparatively a small one; but it was selected as a very favourable specimen of the habit of the tree. The cedar is, generally speaking, a spreading rather than a tall tree; but it attains the height of more than 100 feet. There are many in England much larger than that which we have figured; but descriptions of them are to be met with in all the common books—sometimes accurate, and sometimes not.

In the cones and leaves there is a considerable too, are more expanded, the fasciculi of leaves less so, and the shade of green purer and finer. The cones have the same erect position and firm appearance; they are sometimes single, and at other times in pairs, and they are remarkably full of resin. The resin is a true turpentine, though with a stronger and more aromatic scent than that of the pines; but still it resembles the turpentine of the pines more than the resin of any other trees. Even the timber has a considerable resemblance to that of *pinus sylvestris*, only it is much more resinous, as well as much more compact. In the specimen which M. Lambert has made into a table, and which is a cross section about four feet in diameter, the rings of annual growth are as decidedly marked as in the very best Scotch fir; and their size is such as to indicate a more rapid growth than in Scotch firs of the best quality, while the closeness of the grain is such that the cross section takes a much finer polish than we have ever seen on the Scotch fir. The tint of the whole is deeper, and not so red as that of the fir; the lighter parts are as resinous as the darkest in the fir, and the deep ones are doubly so. Indeed, the whole has a good deal of the aspect of brown agate, as the quantity of resin gives a sort of diaphonous appearance. But, abundant as the resin is, it does not exude much; and, where it does exude, it seems to be much less affected by the atmosphere than the resin of the pines; for, instead of showing any tendency to effloresce, or become powdery, it forms a sort of solid, and apparently very permanent, varnish upon

Deodara.—*Pinus Deodara.*



It must be borne in mind that the habit only of the two cedars is shown in these two figures. The scales on which they are drawn are not the same, as it was wished to represent the cedar of Lebanon on its own timber, and as that would not stand so fine lines as box. The cones should, therefore, be much more nearly of the same size than they are represented; and the chief distinctions in the twigs are the more regular fan-shape of the fasciculi of the leaves in the deodara, and the more regular spiral arrangement of the marks of the bracteæ.

The deodara is probably the most interesting of the whole order of the coniferæ; and though, in its habit, its leaves, and its cones, it resembles the cedar of Lebanon very closely, yet there are differences too great for admitting the two to be varieties of the same species. In habit, the deodara is prone to branch, rather than to rise up in one column; but not so much as the cedar of Lebanon. The twigs, the susceptibility of that country to the action of the sun, the general current of the wind, during the summer half year, is always from the north, and it is warm and dry. When it reaches the snowy summits—those gigantic peaks of granite, which rise, in some instances, to the height of more than 25,000 feet,—the evaporation that it, aided by the reflected beams of the sun from the bare rock and the snow, produces, is very great—equal to the daily melting of the snow. Thus no glaciers are formed, as is the case on the Alps even with a far lower temperature; but a certain quantity of moisture plays daily between the atmosphere and the earth. On the higher slopes, it falls in almost nightly snow, which is, however, melted, and in great part evaporated before the succeeding night; at which time it is again condensed, mingled with what the day's heat has raised from the snow; and both are again precipitated when night comes. It is, of course, only on the higher slopes that this nightly fall and daily disappearance of snow take place; and as the snowy summits are the centres of the action, that must be diminished as the distance from them is increased. In the lofty *ghauts*, or passes, there are rains; and as the mountains are receded from, these given place to dews.

This daily distribution of humidity, under an atmosphere at a very high temperature, is eminently favourable to vegetation; and where that occurs in dense masses, the play of moisture, in alternate evaporation and dew, is very much augmented. Thus, at the very foot of the mountains, on the margin of the plain of the Ganges, the thick forest is involved in an absolute steam, the ground approaches to the nature of quagmire, and the whole is pestilent to human life. Higher up, the climate is less injurious to animal life, and less nourishing to tropical vegetation, of which those pestilent steams are the pabulum; but still the circumstances differ only in degree, and there is a sufficiency of moisture to keep up a strong vegetable action.

Such an action is trying for the mountains themselves, and even the granite is decomposed by the continued alternate freezing and thawing, wetting and drying, till at the end of the summer half year (which is, of course, not measured or terminated by the equinoxes, but begins after the vernal and continues till after the autumnal), the exposed surface, where not clothed and protected by vegetation, is in a state of powder, and ready to be removed by any cause that may act upon it.

And there comes the operation of a cause fully adequate to sweep away the decomposition of one year, and bare a new surface for the next.

When the sun declines southward, and the current of the atmosphere begins to set from that quarter—that current is charged with humidity from the Southern Sea; and, passing over the dry central country of India on the west, or coming directly from the Bay of Bengal on the south, it blazes in lightning, bursts in thunder, and rains deluges, upon the western and southern slopes of the Himalaya, till the whole of the loose matters are forced from the rock; and they descend, mingled with the ruins of the annual vegetation, and deposit in the valleys an annual mass of that species of soil which is most favourable to the growth of trees. Thus there is, as it were, an annual renovation of the soil; and nature herself plays the gardener to those forests upon a scale of the greatest magnificence.

In such a situation, and under such circumstances, the deodara is tempered to all weathers; and, unless when it is absolutely uprooted by the descending torrents of water and masses of gravel and rocks, it does not appear that casualties have much effect upon it, but that it stands in its greenness indifferent to the storms and the changes of ages. The strength of its stem, the firm setting of its branches, its small altitude as compared with the size and strength of its trunk, all fit it admirably for that purpose; and thus, besides its majestic appearance, besides the durability of its timber, besides the fragrance which it emits as a sacrificial wood, the physical strength and living duration of the deodara give it pre-eminent claims to be ranked as "the god-tree," above all the trees of the forest.

SUB-ORDER, CUPRESSINÆ.

Though the cypresses are trees of smaller dimensions and less rapid growth than the *abietinæ*, they are still highly important, and may be considered as holding the extreme, both of endurance and of duration, among arborescent vegetables. They are found in all parts of the world,—in the eastern continent, in America, in some of the islands of the South Seas; and they are the last shrubs that are met with in the extreme cold of the northern latitudes, and also toward the summits of the most lofty mountains. In most of their species they are small, and in some, which grow in very inclement situations, they are low and creeping; but, under more favourable circumstances, other species arise to trees of considerable magnitude, and remarkable alike for the gracefulness of their form and the durability of their timber.

The total number is upwards of fifty; and, like the firs, the leading genera form popular divisions, distinguishable from each other by characters that can hardly be mistaken. With one exception they are evergreens, and, generally speaking, remarkable for the closeness of their leaves, of which the dark tint gives a fine contrast in shrubberies, while the single trees are highly ornamental on lawns.

The most remarkable general habit, in which the *cupressinæ* all agree with each other, and differ from the *abietinæ*, is the formation of buds in the bark, and the consequent property of admitting of multiplication by layers or cuttings—modes of propagation which cannot be successfully adopted with any of the former sub-order. A greater degree of lateral cohesion in the fibres of the timber may naturally be expected to accompany this formation of buds in the bark; and though there be great differences in the strength and toughness of the wood of different species, all of them have more lateral cohesion, in proportion to their general strength, than the abietinæ. They are, however, trees of slower growth, more especially those that are natives of cold climates; and, therefore, they cannot be considered as economical trees in Britain; although the very circumstance of the slowness of their growth adapts them well for ornament, more especially in shrubberies and pleasure-grounds of small extent, to which common forest trees soon become disproportionate, if allowed to exercise their natural habit. If that is not allowed, no tree can be ornamental; for a trimmed fragment of a tree, though we are more accustomed to it, and though we do not associate the same notion of pain with the process of its mutilation as we do with the mutilation of an animal, is as much out of nature, and, therefore, as directly opposed to rational beauty, as a fragment of an animal. The introduction of the cupressinæ, into ornamental grounds in Britain, has had a most beneficial effect upon the appearance of those grounds. There was a time when almost the only evergreen that a citizen could stick in front of his suburban villa was the common yew; or, if there was another one, it was the box. One yew tree, or one box bush, is naturally very like another; and when they are of that small size which suits a little patch of ground, their forms are any thing but graceful; and thus plantations, in which they form the chief evergreens, were all alike, and all equally ugly. Nor was there any means of cure but by *making* them different by the application of the knife and the scissors; and, in respect of absurdity and bad taste, that cure was worse than the disease. It is now almost, or altogether, out of fashion; nor is there any doubt that much of that is owing to the introduction of arbor-vitæs, junipers, and other slow-growing members of the sub-order under consideration, which have the form of handsome trees, even when their height is only a few inches; and thus they can be suited to any spot of ground, however small, and will remain in keeping with it for a very considerable number of years.

One requires merely to look at the cupressinæ, in order to understand why they are so well adapted for ornamental purposes, and why, generally speaking, their growth, as trees, is so slow. Upon a pine the number of buds is very limited, there being nothing in growth but the very extremities of the twigs; and, thus, the points at which an increase of timber can take place are but few; and we need not add that, with equal growth in whole, the average growth, at any one point, will be inversely as the number of points. By comparing a branch of arbor-vitæ, or juniper, with an equally sized one of Scotch fir, it will be found considerably within the truth to state that there are ten times as many buds upon the arbor-vitæ as upon the fir; that is, if the latter contain ten buds the former will contain thirty. Consequently, if we admit that the two trees vegetate equally, during the same period—that is, make equal quantities of matter—it must follow that each bud, on the fir, must make ten times as much matter as each bud on the arbor-vitæ, or juniper. Besides, as the matter made is divided into ten parts, these must have face than one part, and, consequently, more tion of the tree must, in proportion, go to ation of bark. Further, the whole action ne fir is confined to the last year's shoots, in ar as elongation is concerned; and thus, while shoots should lengthen ten times as much as arbor-vitæ, there should be a greater addition wood to the stem and branches; because buds reak out all over the stem and branches of the rbor-vitæ, and all the wood that they make is so uch taken from the quantity that, in the fir, goes elongate the twigs and thicken the stems.

Apparent slowness of growth is almost a necessary consequence of the formation of lateral buds upon any part except the twigs of the former year, and even where the twigs branch in the course of the year's growth they must lengthen less than where that is not the case. The slowness with which a tree of that habit extends is, in the species, in proportion to the tendency to form buds in the old stems, and in the individual it is in proportion to the number of such buds that are actually formed. A tree which stands alone in an exposed situation, so that air can pervade its foliage in every direction, is always bushy and grows slowly. Also when, by being pollarded, a tree is compelled, as it were, to throw out buds all over the trunk, it makes little or no wood, except at those buds and the part of the stem between them and the root. Something, of course, depends upon the closeness with which the tree is pollarded; but, when that is even moderately close, the tree upwards increases very little more. In some pollards, where the unnatural budding does not reach to the ground, and where the natural head is almost entirely removed, the stem may be observed having the form of a cylinder up to the unnatural branches, and that of a cone upwards; whereas, had the same tree been left to nature, it would have had a thick bole and broad head, if standing in free space, and a tall and straight stem, if in a close forest.

As the cupressinæ, in the states in which we generally see them, stand alone—and as, from the smallness of their leaves and twigs, the air plays readily through their masses, they are usually in a state of vegetation from the ground to the summit, and throughout a very great portion of their volume; and thus it is almost a matter of necessity that they should be bushy and run to twigs rather than to stems. Growing at so many points, it is hardly possible that their growth, in any direction, can be great; although in the species which branch at very small angles they run up in handsome spires, and with very considerable rapidity, after they have been for several years in the same situation.

The sub-division of the cupressinæ are *cupressus*, or cypress, properly so called; *taxodium*, or the deciduous cypress; *thuja*, or abor-vitæ; *juniperus*, or juniper; *callitris;* and *ephedra*, or sea-side grape; but the species are so numerous that, in the space to which this sketch is restricted, we can give little more than a mere list of names, especially in the less important species.

§ I. CYPRESSES.

The cypresses, properly so called, are mostly natives of the temperate or warm parts of the old continent, although they are to be considered rather as mountain trees than as inhabitants of the plains. The American species are found chiefly on the Andes.

They are monœcous, have the pollen in oblong catkins, with membraneous scales, shield-shaped, and imbricated. The seed cones are globular, composed of persistant woody scales, supported on a peduncle and shield-shaped at their extremities. The most important species are—

1. *Sempervirens*, the evergreen cypress.
2. *Pendula*, the cedar of Goa.
3. *Torulosa*, the Nipâl cypress.
4. *Pendula* of Japan.
5. *Thyoides*, the arbor-vitæ leaved cypress, or white cedar of North America.
6. *Juniperoides*, juniper-leaved cypress, or African cypress.

Five or six other species are enumerated, but they are not popularly known; they are found in Japan, China, South America, and Southern Africa; and it is worthy of remark that the cypresses of the two hemispheres resemble each other in their leading characters much more than the pines.

Sempervirens.—Evergreen Cypress.

The evergreen cypress has the twigs four-sided and imbricated with the leaves, which are blunt, close to the twigs, and convex; the cones are globular and the branches straight. There are two habits of the cypress, if not two species, the pyramidal and the spreading. The older writers regarded the pyramidal form as the male plant and the spreading as the female, an opinion for which there is, of course, no foundation; nor is it absolutely decided whether both habits may or may not be obtained from seeds of the same tree. Except in the mode of their branching, it does not appear that there is much difference between the trees, and that of itself is not a specific difference.

The southern and eastern sides of the basin of the Mediterranean are the native countries of the cypress,—on the hills of the Levant, in the island of Candia, and on the northern slopes of the mountains of Atlas. On favourable soils, and they prefer those that are gravelly, the trees attain a height of forty or fifty feet. Their branches are close and thick, their forms pyramidal, and their colour dark and gloomy. In consequence, the fabulists of the olden time consecrated them to funereal purposes and to the gods of the infernal regions; independently of the fable they have a melancholy character, and, therefore, they are still associated with melancholy; and, judiciously placed, give a degree of sentiment to the scenery of which they form part. Though hardy trees in their native places they do not bear well either the cold or the humidity of northern winters. They give a peculiar character to the countries in which they are found; but, probably, the south of France is the most northerly latitude at which they can be cultivated as timber trees.

In places where they do grow their timber is very valuable. It is hard, perfumed, of a very close grain, and uniform reddish colour, which does not change with time; it is, therefore, well adapted for cabinet work, organ pipes, and the general purposes of turnery. The timber is very durable, so much so, that the Romans employed it for purposes where durability was an object, and Pliny mentions a statue of Jupiter, in the citadel of Rome, which had lasted for six hundred and sixty-one years; while the doors of the church of St. Peter's at Rome, formed of the same material, are said to have lasted for twelve centuries. It is no very easy matter to get connected evidence of the identity of the same doors for so long a period; but still the statement may be true, and would lead one to conclude that the long-lasting beams mentioned in history, as having been formed of cedar of Lebanon, were cypress; the spreading variety of which might, by a common observer, be easily confounded with the cedar.

The *pendulous cypress* of Goa, which is now sometimes called Portuguese *(Lusitanica)*, from its having been introduced and to a considerable extent naturalized upon the mountains of Portugal, differs considerably from the former in its habits. Its branches, instead of being stiff and rigid, are drooping, and its colour is blueish.

The natural habitat of this cypress is tropical, being on the western mountains of the Indian Peninsula, at about the latitude of fifteen degrees north. On those mountains it once formed extensive forests, and the timber was in request in commerce. Goa was, in the time of Portuguese ascendancy in India, the chief place from which it was exported, and hence its common name; from India it was transported to Portugal, where it grows in considerable numbers, especially upon the mountain Busaco, near Coimbra, for which reason it is sometimes termed the cypress of Busaco. When the tree is in a favourable soil and is left to its natural habits the stem rises perpendicularly, which with the flexible and pendant branches give it an elegant appearance, and its blue tint makes it a good variety among greener trees. It is probable, however, that Portugal is the highest latitude that it will bear in Europe, and, therefore, the introduction of it, even as an ornamental tree, is impossible. Perhaps the cedar of Goa suffers less from extreme heat than any other forest tree—certainly than any other which will stand the climate of any part of Europe.

The *cupressus pendula*, and *pensilis*, which are found in the more northern and temperate climates of China and Japan, probably differ a little more from that of Goa than can be accounted for by mere difference of climate. The pensilis, in particular, is so delicate in its twigs that it has a good deal of the air of the *Salix Babylonica*, and is sometimes, though of course improperly, termed the Chinese weeping willow.

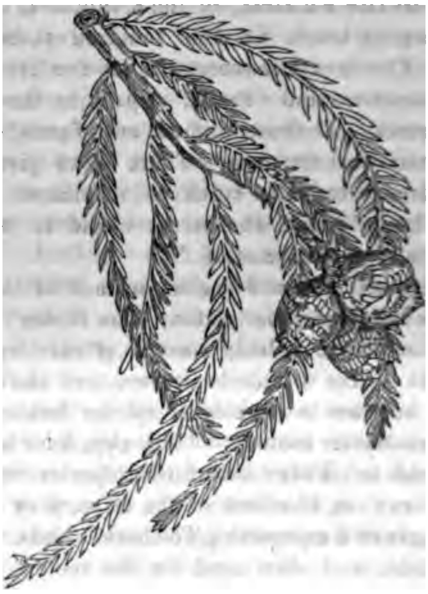
The *torulosa*, of the Himalaya, has more the character of the evergreen cypress of Western Asia. The numbers in which it abounds, or the proportion of the forest which it forms upon those mountains, have not been particularly ascertained.

The *arbor-vitæ-leaved cypress*, or white cedar, is a native of the central latitudes of North America, where, upon moist soils, it grows to a great height;

its timber is white, light, flexible, easily worked, and durable in water; and it is used extensively for many purposes. The trunk increases slowly in thickness, and a stem, eighteen inches in diameter, contains upwards of one hundred years' annual growths. In consequence of its flexibility it answers very well for hoops. The branches are flat, the leaves imbricated, of an oval figure, and have tubercles at their bases. There is no question that this species could be cultivated on rich marshy soils in England; but whether it would be worth the culture is another matter.

The *juniper-leaved cypress*, instead of having the leaves imbricated on the four sides of the twigs, has them opposite. Being a native of the Cape it does not stand the winter in Europe, and the same remark applies to some other species that are natives of the same country. The cypresses of South America are little known in Europe, and the probability is, that, like those of the Cape, they could not be cultivated except as greenhouse plants.

§ II.—TAXODIUM.



Taxodium disticha used to be classed with the cypresses, although they are all evergreens, and it is a deciduous tree, and differs from them in many of its characters, and, indeed, in its general aspect. Its leaves are in two rows, of a fine green, and the whole tree has a light and elegant appearance; it grows in the central parts of North America, intermediate, as it were, between the pines of the north and those that occur in the mountains of Mexico. It is a tree of very large dimensions, and, with the exception of the recently discovered pines to the westward of the mountains, it is one of the largest trees, if not the very largest, in the country. The trunk is sometimes nine or even ten feet in diameter, and fifty or sixty up to the branches. A trunk of those dimensions furnishes timber adapted for any purpose for which size alone is required, and the trunk is sometimes excavated into large canoes in the same manner as the *kawii* tree is by the natives of New Zealand. It prefers humid soils; and will grow even where the surface is several feet under water. The timber is yellowish and soft, of little specific gravity or strength; but it is free from knots, clean, very easily worked, and answers remarkably well for house purposes, especially for roofing and shingles, for which last it is said to answer better than harder and heavier timbers; as it is not so apt to warp or champ by changes of temperature. The bark is also compact and durable, and often used for the roofing of houses. Upon the whole the tree is a highly serviceable one.

One of its most singular habits is the formation of exostoses or lumps upon the roots, which often attain a very considerable size. These exostoses form in considerable numbers and stand above the surface of the ground, very much like lumps of brown stone that have been rounded by the action of waters. They do not, at least for a long time, put forth any twigs, or even leaves, and they have been found several feet in each of their dimensions without any indication of sprouting. The woody vessels in those lumps are, of course, convoluted, in the same manner as they are in the tubercles which form in the bark of beeches and some other trees; but it is peculiar that, in the taxodium, they should form on the roots only, and grow to so large dimensions. Their formation is evidently a natural habit of the tree and not a disease; for they are invariably found after the tree has attained certain dimensions, and the roots have extended to a certain length. No trees can be more healthy than some taxodiums that form part of the interesting collection of American trees at Sion House, and yet the exostoses are so abundant on the roots of these, that, in some instances, they have had to be hewn off, as they interrupted the walks.

In Britain, the taxodium can never be considered in any other light than an ornamental tree, and that only in peculiar situations; for though the roots run to breadth rather than penetrate deeply into the ground, the soil requires to be both rich and humid. From its deciduous leaves it is only seasonal, but then its graceful form and its fine colour make it highly ornamental; and, as is the case with many of the deciduous trees of America, the leaves fade into a rich tint before they drop off.

From the habit of the tree it might be inferred that cuttings of them will grow; they also stool on the roots when cut down. The cones contain a resinous matter, which is fragrant, leaves a reddish glittering stain upon paper and might possible be used as a varnish.

§ III.—Arbor-vitæs.—Thujæ.

Besides their mere external characters, the arbor-vitæs are distinguished from the cypresses by their cones being more of an oval form and having seeds with membranous wings at the edges. They are, at least in some of the species, much more hardy trees than the former, and inhabit colder climates. They are also trees of smaller dimensions than these; and they are of much finer appearance, and thus suit better for ornamental planting. The leaves are at first of a very bright green, which fades into a bronze green as the winter approaches.

The arbor-vitæs are widely scattered over the surface of the globe in the eastern continent; they are found from the confines of Siberia to the south of Africa; or, rather, they are found toward both extremities of that immense range in latitude. They are also found toward the extremities of the American continent; and they do not occur, at least they have not been mentioned, upon even the mountainous parts of the tropical portion of either continent. Some of the species are common both to Asia and America. The external characters by which the arbor-vitæs are most readily distinguished from the cypresses are — first, the flatness of the branches, which, both in the entire branch, and in the little branchlets of which that is made up, are flattened, or have the form of plates, and they have that form even when their position is nearly vertical, so that the parts of the tree may be opened from each other, something after the manner of the leaves of a book; and secondly, the colour, which has none of the gloomy tone of the cypress, even when it fades to its winter hue.

The two species that have been longest known in Britain are the Chinese arbor-vitæ *(thuja orientalis)*, and the American arbor-vitæ *(thuja occidentalis)*; but the last is both an eastern one and a western.

The American arbor-vitæ is the species which has been longest known in England, for it was cultivated by Gerard as early as toward the close of the sixteenth century. It is a very hardy plant, being found upon the hills, and by the river sides, in Canada, so that it bears the winter in any part of Britain. Its growth is very slow, from the great division of points at which vegetable action is carried on. Kalm counted ninety-two annual rings in the transverse section of a trunk only a foot in diameter, and one hundred and forty-two in another only fourteen inches; so that, in the latter, the increase, taking both sides of the ring, was only at the rate of about one inch in diameter in five years. Nothing is said about the relative thicknesses of the rings at different periods of the growth; but it is not improbable that, as the number of buds fully keeps pace with the increase of size, they are uniform throughout the whole duration of the tree. The absolute period to which the tree will last is not ascertained; but there is evidence of so prolonged a duration, without any symptom of decay, as to show that the tree is not undeserving of the common epithet—vitæ.

This species, in favourable situations, rises to the height of thirty or thirty-six feet, though in most cases it is a shrub rather than a tree. The timber is light, and very tough and flexible; but it is durable, and stands well either in the ground as posts, or exposed to the weather. When of sufficient size it is valuable in turnery, while the leaves are said to have some medicinal qualities.

The Chinese arbor-vitæ is very similar to the former species in many of its characters; the chief ones in which it differs are, having a channel in the middle of the leaves, the cones more elliptical, and the lower extremity pointed; whereas the leaves of the American species are without the groove, and the cones are rounder, and have the lower extremities thicker. The Chinese species grows even more slowly than the other, and hardly attains the same dimension. Its timber is harder, and still more durable, and the tree itself is more ornamental, and the smaller specimens of it are more finely shaped. It grows abundantly in China, in Japan, and in some other parts of Asia; and though it be a more southerly tree than the American species, it bears the winter very well in most parts of Britain.

It is by no means probable that the *thuja* mentioned by Theophrastus, as growing near the temple of Jupiter Ammon, could have been any of the species now mentioned, or even one of the thujæ of the moderns at all; for none of these is now found in the situation which he assigns to it; and none of them is entitled to the character of a large tree, which he also gives to his species. He men-

[illegible] the resemblance which that thuja bore to the wild cypress; and it is probable that it may have been either the upright or the spreading variety, and that [illegible] had known only the other as a cypress. Indeed, when the accounts of the cedar of Lebanon, of the thuja, and of some other trees, are considered, a probability arises that the southern part of the Levant, and the north of Arabia, may have, at one time, been as remarkable for forests of cypress as Germany was for forests of pines; and that they have in great part perished, owing to the change toward drought that has unquestionably taken place in the climate.

The only species of arbor-vitæ that can be considered as native in Europe is *pyramidalis*, which is found in Italy. There is another on the northern slopes of the mountains of Atlas, of which the twigs are flat and jointed, and the cones formed of four scales, which give them a quadrangular appearance. In the mountainous parts of Algiers these trees attain a size nearly equal to that of the American arbor-vitæ—that is to say, about thirty feet in length and one foot in diameter; and it is said that they are still larger in Morocco. It is said that sandarach, a whitish, resinous substance, of a bitter aromatic taste, exudes from this species of thuja; but some of the authorities refer it to one or other of the junipers, and it is not impossible but that it may be produced by both trees.

There is at least one other African species of arbor-vitæ, the cypress-leaved (*thuja cupressoides*), which grows at the Cape of Good Hope. Its branches are elongated, and resemble those of the cypress more than any of the species that have been mentioned. The cones are globular, but they have four angular ridges arising from an equal number of scales. Were it not that the present habitat of that species is so far from that mentioned by Theophrastus, the aspect of this arbor-vitæ answers fully as well to his thuja as any of the others.

Besides the orientalis there are other species in the eastern parts of Asia: *dolabrata*, in China, and, in all probability, several others in the country farther to the west. There are also some other species in North America, as *plicata*, in the west, toward Nootka Sound, and *spheroidea*, in other parts of the country; nor is it by any means improbable that farther researches may find additional species among the other coniferæ of the southern parts of the American continent. Most of these are, however, merely shrubs, or at best but small trees; and though they are all handsome, and furnish good timber in proportion to their sizes, they want the majestic character which so peculiarly belongs to many of *abietinæ*; and the very circumstances that render them so ornamental as shrubs, destroy their character as forest trees. A forest tree is never grand unless it displays a lofty column of stem, and a graceful spiry top, or a wide expansion of branches; and an arbor-vitæ, upon a tall single stem, whatever were its dimensions, would be as likely to suggest the idea of a gigantic broom stuck into the ground as any other comparison.

§ IV.—JUNIPERS.

nipers are a very numerous and highly sting genus of plants. They are more widely ibuted than almost any other; and, though not many of them grow to stately dimensions, their ber is durable and useful, and their products are l to some purposes in the arts. Taking the nge of their characters, the junipers may be sidered as holding the extreme limit of arboscent or shrubby vegetation. For though a few species grow in low swampy grounds in temperate regions, and a few in tropical countries at no very great elevation, the junipers are the last shrubs toward the polar ice in the northern hemisphere, and the last toward the perpetual snows upon the summit of almost every mountain ridge that rises so high as to have a never-thawing mantle. Their habits, and the dimensions to which they grow, vary greatly, not only in the different species, but in the same species in different situations. That may be expected, as well from the vast range of climate over which they are distributed, as from the variety of soils on which they will vegetate. It is difficult to imagine a soil too poor or too cold for the production of junipers. The common species, which is abundant in most of the elevated and unprofitable parts of Britain—which, on the best soils that it inhabits, forms a sort of coppices, and upon the worst creeps along within a few inches of the surface—is found in bogs, on rocks, and over gravel, so barren that heath will not grow on it to the height of an inch. It is very widely distributed; being found at North Cape, in the dreary countries to the eastward of the White Sea, in Siberia, and in the northern parts of America, in all of which situations it is shrouded in snow for more than half the year, and has to contend with the ice-brash for great part of the remainder. It is found again on the summits of the Carpathian mountains, where those summits are too bleak for nourishing even the stunted growth of the mugho pine. It occurs on the Alps, on the Pyrenees, the elevated tracts around the Mediterranean, the Altaian mountains, the hills of Japan, and the Himalaya. Although it endures the extreme of cold, it does not appear that cold air is the circumstance most favourable to it. Poverty and coldness in the soil seem more congenial to it; for, in some of the wretched chalk-soils in the south of England, it is found at lower elevations, and far more stunted in its habit, than in some places much farther to the north. Humidity seems favourable to its growth; and thus it creeps along in those places where, melting of snows, ground saturated with moisture, or some other cause that keeps the atmosphere charged with vapour in the summer months. For that reason it is, like the cloud-berry, and some other natives of the margins of the snow, shy of growing in rich ground; and, therefore, though a native, and a hardy native, it is not so well adapted for an ornamental evergreen as the arbor-vitæs, which are natives of much warmer places.

The species of juniper are very numerous;

ur, at least, are described in the cata-
ad it is probable that there may be others
of those regions that have not been com-
xplored; but in plants of which the size
are so much varied by situation, it is not
n ery easy to decide, without a very careful
ation of the cones, or berries, and the seeds,
e the species, and what mere varieties. Asia,
n g the greatest diversity of climate, is most
undant in species or varieties of juniper; the
gest ones are met with in America, and the
lombian Archipelago. There is but one species
Southern Africa, two in Australia; and none are mentioned as occurring in South America.

The junipers are easily distinguished from the cypresses and the arbor-vitæs by their cones, which always contain three seeds, or a greater number, have the scales soldered into an entire envelope, though still with the junctions less or more marked; and during the second year, as they ripen, the external portion changes into a sort of pulp externally, of some shade of brown-purple or black, and they are pungent and esculent. Those characters vary considerably with the species, but still they are decisive that the plant is a true juniper, and not one of the other genera of cupressinæ.

European Junipers.

The common juniper *(J. communis)* has been already mentioned as hardy, and generally diffused. It has the leaves in threes, slender and pointed;

and the cones or berries are abundant. In countries where the juniper attains any considerable size it is very valuable as a timber, in consequence of its hardness and durability. When sufficiently straight it makes excellent walking-sticks, and the roots are made into cups, and other small articles of turnery. The wood of juniper contains a considerable quantity of the peculiar essential oil which is employed in flavouring the Geneva or gin of Holland, and the names of that spirit are derived from the French name of juniper, *Genévrier*. That oil is given out freely by the berries, and even by the timber, to alcohol in any form; and thus any spirituous liquor may have the Geneva flavour communicated to it; only when that flavour is given by the oil obtained separately, and not by the berry, the quality and flavour are both inferior. When the berries, or even the wood in sufficient quantity, are used in substance, through the processes of fermenting and distillation, something more than the mere essential oil is obtained; and when the oil is got in a separate state, by the common process of obtaining essential oils, something additional mixes with it, and injures it. From the berries in substance, a peculiar aromatic bitter (possibly sandarach, or something resembling it,) combines with the oil and the spirit; but it does not rise along with the oil in the process for obtaining the oil. In that process there is a small portion of an empyreumatic oil formed, and also a quantity of acetic acid; and these two together form the common pyroligneous acid, which is so offensive in its taste, and so deleterious in its properties, until it has been freed from the empyreumatic oil and rectified into common vinegar. Thus, it is not possible to make an imitation of Geneva, or, indeed, of any other spirituous liquor, that is flavoured by a vegetable substance, by any subsequent chemical operation, how skilfully soever it may be performed. The alcohol may always be obtained pure, however vitiated it may be at first; but there are no means of obtaining a flavouring matter that shall have all the good qualities of the same oil from the vegetable in substance, or that shall be free from bad qualities in addition. The extract of juniper leaves is understood to be stomachic, and it acts considerably, though mildly, upon the kidneys. The Laplanders use the decoction as tea; and the odour given out by the berries, and also by the wood, when burning, is said to destroy noxious miasmata. In many parts of the north of Scotland the smoke of juniper is used in curing fish and hams, to which it communicates a peculiar, and by no means disagreeable, flavour; but it is so pungent that the places where the operation is carrying on can hardly be entered with impunity. The wood is of a good colour, and slightly marked by the annual rings. There is a smaller juniper *(montana)* found upon the Scottish mountains, which has not been met with of any size that would entitle it to be reckoned as even a small tree. We have met with the common one upon moist slopes in the Grampians (on the Badenach side, near the Spey), having a portion of the trunk eight or nine inches in diameter; but we have never seen it more than ten feet high, and rarely as much.

Other than those that have been mentioned, there do not appear to be any British species. *J. Suecica* is mentioned as occurring in Sweden, and having the leaves more pointed, and the branches more erect, than the common.

In the south of Europe, one of the most remarkable species is the savin *(J. sabina)*. It is rather a handsome plant, with numerous spotted branches imbricated with small green leaves, and some of the habits of the cypress. In its native regions the savin grows among the rocks; but, as it is not very delicate in respect of soil, it may be cultivated as an evergreen shrub in most situations in Britain. The berries have a more blueish tint than those of the common juniper; and the plant has a stronger and less agreeable odour, and more active qualities. Indeed, the preparations of it are so strong that, in large doses, they act as a sort of poison.

These trees are not confined to the south of Europe, but are found in other regions surrounding the basin of the Mediterranean.

The principal other species found native in the south of Europe are *oxycedrus*, in Spain and Portugal; *thurifera*, in the same countries, and *hemispherica*, *Phœnicia*, and *Lycia*, in the countries near the Mediterranean, as well as in Sicily, and several others of the Mediterranean Isles. Oxycedrus is a considerable tree, twenty to twenty-five feet in height, and from a foot to eighteen inches in diameter; it grows in dry and uncultivated places—has its leaves in threes, hard, stiff, and pointed, but longer, broader, more flattened on their under sides, and closer, than those of the common juniper. Its cones, or berries, are brownish, and about the size of sloes. This species affords an empyreumatic oil, which is employed in animal medicine, chiefly with a view to retard ulceration, which the extracts of most of the junipers do. This juniper does not bear the winters of Britain so well as the savin.

The Phœnician juniper is only a shrub, seldom exceeding twelve feet in height; but it is handsome, and has the farther advantage that, though a native of countries rather warm, it can bear a considerable degree of cold. Its form is pyramidal; its branches numerous and close, and its twigs covered with small and thickly serried leaves, having considerable resemblance to those of the cypress. Its timber is hard, about the same size, and possessing nearly the same qualities, as that of the common juniper.

Thurifera, or the Spanish juniper, as it is sometimes called, is a tree rather larger than oxycedrus, and is, perhaps, the largest of the European species. It is found upwards of thirty feet in height; its leaves are slender and pointed, and placed in four rows; its ripe cones are larger than those of the common juniper, and of a red colour. Thurifera is not, by any means, an appropriate name, as the *thus*, or frankincense of the ancients, from whatever tree it may have been obtained, certainly was not a product of this juniper. The Spanish juniper is rather delicate, bearing cold ill, and a very humid atmosphere worse.

Asiatic Junipers.

Besides those species which are common to Europe and Asia, there is, on the mountains of Asia Minor, and the southern parts of Siberia, the tall juniper, which rivals the cypress in height, and has an esculent fruit, little inferior in size to a walnut. In the same habitats the *oblonga*, and *nana*, probably a different species from the montana of Scotland, are met with. In the south-east of Siberia the *Daourica* occurs, and there are the *Chinensis*, and the *glauca*, in China; and *squamata* and *recurva*, on the mountains of Nipâl. In none of these situations, however, can these be considered as giving a character to forest scenery in almost any part of the old continent, as the places in which they are chiefly found are too cold or too arid for the production of lofty trees. They are the wastes of nature, or the patches of land between the rocks.

African Junipers.

Some of the species of southern Europe occur in the north of Africa, between the mountains of Atlas and the sea. Indeed, there is a considerable resemblance between the vegetation of that country and that of the northern and eastern shores of the Mediterranean; and the proper African character does not begin till the mountains are crossed toward the desart. It does not appear that there are many, or, perhaps, any coniferæ, from the desart southward to the country of the Cape; and only one species of juniper has been discovered there—*juniperus Capensis.* That species is a very bushy tree, having the leaves on the upper part of the branches in threes, linear and pointed, green on the under sides, and blueish above. From its climate, this species cannot be cultivated in Britain, except as a hot-house plant.

American Junipers.

Three of the American junipers are important as timber trees, forming extensive forests, and rising to considerable height. These are *juniperus Virginiana,* the red cedar of America; *juniperus Bermudiana,* the Bermudas cedar; and *juniperus Barbadensis,* the Barbadoes cedar. Though they are all vulgarly denominated cedars, none of them has much of the habit of the true cedars, for they are spiry trees, and, in their general characters, decidedly junipers. At the time when America was first colonized by Europeans, the Virginian cedar formed vast forests, and it is still met with abundantly in some parts of the country, although in many parts it has been destroyed, and the loss not supplied by planting. The trees grow close together, are spiry, but lose their lower branches in consequence of the exclusion of the air by those above, and thus form long and valuable stems without any branch, and these are surmounted by pyramids of foliage. The leaves are in threes, imbricated in their early stages, but spreading as they become old; the cones are small, oblong, and turn blue as they ripen. When standing alone, and with its branches down to the ground, the red cedar is a very handsome tree, perhaps the most so of any tree of the same pyramidal form and close foliage; and as its growth is rapid, at least after it has stood a few years, it is a highly ornamental tree for parks or lawns, and has the advantage of being valuable as well as ornamental. The red cedar sometimes attains the height of from a hundred and twenty to a hundred and fifty feet, and with a diameter so considerable that it admits of being hewn into canoes of considerable dimensions. The timber is of a reddish colour, from which the name of red cedar is given to it, and it is close and durable. The houses in America that have been constructed of it last for a considerable time; and it is adapted for many useful purposes. In consequence of the vast number of its buds and twigs, the increase of diameter is not very rapid, there being about a hundred and fifty annual rings in a trunk eighteen inches in diameter. In some situations it increases much more rapidly, the annual growth being from a tenth to three-fifths of an inch, which is fully equal to the average of durable timber.

The same species occurs in the West Indies, where it grows to a size little inferior to that which is in North America; and it is there one of the most serviceable timbers, as very large boards can be formed of it. Its odour is a little pungent, but not disagreeable, unless to insects, and that increases its value in countries where substances are so much exposed to their ravages. The tree is d bears the winter well, and may be grown ently on arid soils, or on swamps; and, there- it is rather a desirable tree for cultivation.

he *Bermudas* cedar is found abundantly in the ands after which it is named; and though it does t attain the same size as the last-mentioned spe- s, it is equally valuable, if not more so. The ual height is from forty to fifty feet, and the iameter about one foot. The branches are very umerous, and come off at small angles to the stem; e leaves are imbricated, pointed, arranged three d three, or four and four. They are of a bluish colour on the upper sides; and as the tree advances in age they get smaller and shorter. The ripe cones change to a purple red; the timber is soft, light, of a reddish colour, and clean in the grain, but weak, brittle, and splintery; it is the well-known cedar of commerce, used in the manufacture of black-lead pencils, and for various cabinet works, especially for the interior of drawers and boxes, for which it is well adapted, in consequence of its smell, which is a good preservative against moths. The Bermudians construct boats of it, which are remarkably buoyant and fast in the water, and are said to last longer than those constructed of harder and heavier timber. As the climate of the Bermudas is warm, this species will hardly stand the winter in Europe; but it thrives well and grows rather rapidly in its native islands, gives there a decided character to the scenery, and constitutes a considerable part of the wealth of the inhabitants.

The *Barbadoes* cedar has a considerable resemblance to the two species last mentioned—is one of the largest timber trees in the West India islands, and one of the best adapted for ship building.

The other species which are peculiar to North America are of inferior dimensions, and are hardly worthy of being mentioned as timber trees; they are of small dimensions, and, in a popular point of view, more resemble the European junipers.

§ V.—CALLITRIS.

The plants to which that appellation is given are a singular genus; for though they have the habits of trees or shrubs, produce the seeds in cones, and agree with the cupressinæ in their general botanical characters, they may be considered as leafless, and, in some respects, intermediate between the leaved coniferæ and the *equisetums*. There are at least eight species, one of which is found in Barbary, and all the rest in New Holland. In that country some of the species, as *arenosa* and *pyramidalis*, are trees of robust habit, rising to the height of fifty, or even seventy, feet. They grow in the poorest soils, on the sandy shores about Moreton Bay. The timber is not difficult to work, and it takes a good polish; but it is short in the grain, and unfit for any purpose where strength is required. Indeed, it is not very fit for any purpose whatever, unless very temporary ones, for it champs and splits in pieces as it dries, thus indicating that it has no lateral cohesion except what it derives from the sap. On the island of Rottennest, on the west coast of New Holland, there is another species, *robusta*, which is a good deal the habit of the cedar of Lebanon, but the value of its timber has not been ascertained.

§ VI.—EPHEDRA.

There are three species of ephedra, two of them natives of the south of France and Spain, and one of the mountains of Tunis and Algiers. They are vulgarly denominated "horsetail" plants, from their habit; and, to distinguish them from the herbaceous horsetail *(equisetum)*, they are styled shrubby; they are also called "sea grapes," from the appearance of their cones or berries, and from the fact of the European species being found near the coast.

They are singular-looking plants, consisting of an immense number of twigs or branches, forming a thick bush, evergreen, and leafless. Each branch is composed of a number of joints or pieces. Their flowers are small, yellowish, and very abundant, and the cones or berries turn red as they ripen. Where they stand the climate they agree best with light, dry, and sandy soils, and make rather a handsome variety.

European species are—*ephedra disticha*, the great sea-side grape; and *ephedra monosticha*, the small sea-side grape; the distinction, besides the difference of size, being that the *amenta* are in pairs in the first, and solitary in the second.

The species of northern Africa is the *altissima* of Desfontaines. It rises to a greater altitude than either of the former species; and its numerous, long, and pendant twigs give it both a singular and a handsome appearance.

The above paragraphs do not profess to give a complete list of the cupressinæ, but merely notices of the principal ones; and illustrative cuts have not been added, because fragments, on which the leaves and the cones are so minute, would convey no useful information.

SUB-ORDER, TAXINÆ.

The taxinæ form the last sub-division of coniferous vegetables. They are less numerous than those of the other divisions, and, between some of them, there is a good deal of dissimilarity, at least in their external appearance. Their name is taken from that of the common yew *(taxus)*; but some of the genera have very little similarity to that tree in their habits. In general, however, there is some external resemblance; and the more minute and essential characters agree.

The taxinæ differ a little in their localities from the other sub-orders. They are not found in so high latitudes or at so great elevations upon the mountains, and they prefer better soils. In those respects the particulars are not, however, very well known, as, with the exception of the species after which the sub-order is named, there have not been very many opportunities of studying the others. Taken as a division it may be stated that, whatever may be the hardness and strength of their timber, it is

ns, and approaches more to the nature of
gelatinous sap, than that of the other sub-
t is true that resinous wood is not a uni-
acter even of the abietinae; but still,
aucarias, and other bers of that sub-order
h are without resin in the wood, have it in
bark; and, therefore, taken as a whole, they may
onsidered as resinous trees. Thus, in respect
the resin they contain, there is a regular gra-
ion; the abietinae have it in the greatest abun-
ce; the cupressinae contain less, and the taxinae
e still—hardly even a trace in some of the species;
respect of durability of timber, therefore, either as resisting splitting, and separating into fibres, or as withstanding the decomposing action of the atmosphere or of water, there is a gradual decrease, supposing that the ligneous vessels are equally firm in their texture and their union. The abietinae are, with the exceptions that were formerly noticed, embalmed and cemented together by their turpentine; and, consequently, they are thereby fortified both against accidents and against time; so that spongy timber in them, though lighter and more flexible, resists strain and decomposition better than more firm timber which is not so cemented and preserved. The cupressinae, having less of this resinous cement, and what they have being of a less tough and adhesive nature, depend more for their strength and durability upon the compactness and union of the ligneous fibres. As most of them are very slow of growth, and all of them form buds in the bark, and thus indicate more lateral action than the

abietinæ, the timber of most of them is durable; but, when they grow in warm and moist climates, as is the case with the larger American species, the wood, though clean, is tender and easily split. As the taxinæ have still less cementing matter, they, of course, depend still more upon the adhesion of the ligneous fibres; and though, in the common yew, the only one with the timber of which we are well acquainted, the durability is considerable, it is much less so in proportion to the closeness and weight of the wood than in the pines; while, in some others of the sub-order, decomposition and drying are contemporaneous and take place in a very short time.

So far as is known, there is the same connexion between rapidity of growth and speedy dissolution that occurs in many other families of trees; and that holds not only in respect to the different genera and species, but also in different individuals of the same species. Yew trees of dwarf dimensions, that weather the blasts of ages, high up on the mountain sides, and attaining, in a long time, trunks only a few inches in diameter, remain all the while as solid as iron; while those that grow in rich soils—the stately park and churchyard yews for instance—and attain yards of diameter in the same period, become decayed and hollow, till the shell, or portion of shell which still retains its vitality, contains little more solid timber than the stunted specimens before mentioned.

It is extremely probable that the foundation of this decay is laid in the early period of the growth

s. It is a pretty general law, and was in the instance of the cedar of Lebanon, owth of trees of long duration is at first ow, however it may increase afterwards. es, upon soils richer than those upon which they ce the best timber, are always softer in the centre than they are toward the circumference of the tured and hearty wood; and, indeed, so far as ervation has gone, it may be considered that a w growth in its early years is essential to the fortion of good and durable timber, in very many of coniferæ. Nor is the cause difficult to be un- rstood. In the young tree the quantity of pabulum received is greater in proportion to the elaborating apparatus than in a tree of full size and in full vigour. From the proportionally greater number of branches, the cambium, in such a tree, is distributed over a greater extent of surface in proportion to the volume of solid; and, for the same reason, the leaves, in which the great change takes place, are more numerous in proportion. Hence, a very young tree may be weakened by over nourishment and over development, where the same plant, at a more advanced age, would not suffer. There are other proofs; large yews in low situations and on rich soils are very generally hollow; while the trunks that are dug up in the mountain bogs (and there are numbers so dug up in Ireland), are generally sound, or when they are decayed the decay is at the surface or generally through the mass. Besides, it is found, by experience, that pine plants make the best timber when they are grown in bleak situations and in cold and peaty soils. Nor does the difference arise from the check given to the vegetative power by the pause during their transplantation, or by the transition from the rich soil of a nursery-ground to the poor one of a common or heath; for that would tend rather to the destruction of the plant than to a more rapid growth and softer timber. The subject of the adaptation of food to plants, both as to quantity and to quality, is a most important matter in an economical point of view, more especially in plants of the description alluded to, which are cultivated for the timber. But it is a subject of very great nicety and very great difficulty; and in consequence of these, and of the partiality which every cultivator naturally has for his own mode of culture, it is one upon which there cannot but be a great deal of misunderstanding and error. The length of time necessary for even one accurate experiment is almost conclusive against the accuracy. Cultivators are far from agreed as to the best modes of treatment in the case of annual plants, which take only a few months from the sowing of the seed to the maturity of the crop; and, therefore, if we assign only one hundred years for the full maturity of a pine, or two hundred for that of a yew, who has kept, or who can keep, or be expected to keep, an uninterrupted register for half that period? What may be done in future it is not easy to say; but, at any past period, numerous theories, all contradictory of each other, would have risen and set in the course of the inquiry; and thus, both the inquirer and the object

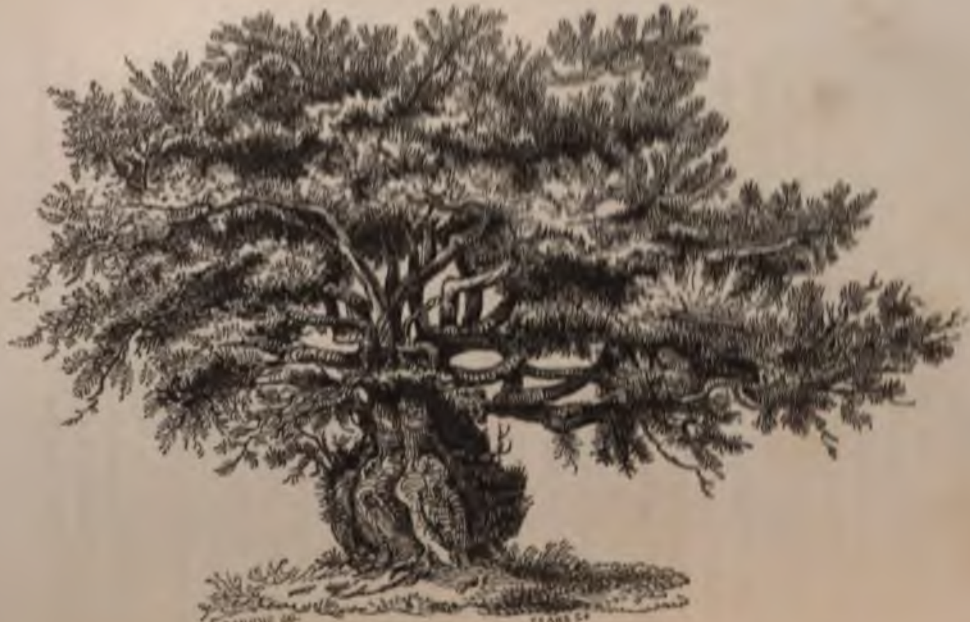
ies would have changed; and the experi-
ld not have been one but many—and
ling and confusing each other. But we
getting the taxinæ:—

he sub-order contains at least four genera,—
s, podocarpus, dacrydium, and phyllocladus; the
er of species, hitherto discovered, is not, how-
r, very great, and it is possible that some of
m may be merely varieties. With the exception
he common or berry-bearing yew (*taxus baccata*)
y are all natives of distant countries; and they are
ely scattered, some in the north of America,
me in the West India Islands, some in Chili, some in New Holland, some in the Malay country and on the mountains of Nipal, and some in China and Japan: so that, with the exception above mentioned, they inhabit round a circumference of which Europe is nearly the centre.

The common yew is very generally distributed over that part of the eastern continent in which none of the others are found. In Europe it extends from Sweden southward; and from the shores of the Atlantic indeterminately into Asia. It does not generally occur in forests or even groups of much magnitude or closeness, unless at very particular spots; but is scattered about in single and spreading trees, which do not thrive well closely intermixed with others, or suffer others to thrive under their shade. In its more northerly situation it is now chiefly found in low, rich, and rather humid places; though there are vestiges of it at some elevation, yet never near the perpetual snow. In the central parts of Europe it is found on the plains; as the Alps are approached its situation is a little higher; on the Pyrenees it is still more so; and the height increases as the climate becomes warmer; but it is never, upon the average, so far up as the spruces and mountain pines, and always much lower down than the mountain junipers. The yew may, therefore, be considered as a native of temperate and somewhat humid climates, and as partial to fertile soil; though, as has been said, it grows and makes very durable timber, though of comparatively small size, on places that are bleak and exposed. Shade is, however, more congenial to it,—at least, more conducive to rapidity of growth and largeness of size. Even under the circumstances the most favourable to growth, it grows slowly.

The yew is not under any circumstances a very lofty-growing tree, and rarely exceeds fifty or sixty feet in height; but the trunk swells out to a great size, and is often, in old trees, of fantastic and by no means unpicturesque form. The specimen which is copied on the frontispiece of this sketch is by no means one of the largest to be met with in England; but it displays some of the peculiar habits of the tree, and shows that, after the greater part of the heart is entirely gone, the remaining wood continues to vegetate in almost all directions. The trunk of that specimen is not above nine inches in thickness from the hollow to the external circumference. It is open quite to the level of the ground, and also at top in the middle of the branches; so that the tree has some resemblance to a vase in a state of vegetation. Except one in the side opposite to that shown in the cut, there is not any perforation worthy of notice, saving the opening at the top. The lateral opening is shown in the cut on the last page of the volume, and it is small, though recently it was enlarged in order to extricate a cow that had entrapped herself by the horns, and struggled bellowing for relief until a portion was sawed off. It has been mentioned by many authors, from the time of Theophrastus, and there is some reason to believe that the statement is not wholly unfounded, that the leaves and twigs of the yew are poisonous to cattle. But probably the instance mentioned is the only one in which a yew tree had a chance of becoming an executioner. Nor was it to the quadruped only that it had some effect in that way; for not many years have elapsed since a young woman in the neighbourhood, in the agony of slighted vows, pledged in all probability under the spreading branches of the tree, put a period to her existence by suspending herself from one of them, and now lies interred immediately below. It may be mentioned also that the local authorities, while they interred the misguided girl within the consecrated precincts of the churchyard, took summary and somewhat silly vengeance upon the tree, by lopping off the branch,—the stump of which is shown as the second from the reader's left hand in the cut last alluded to.

The general representation of the tree is taken from the point where the curious ramification of the branches is best seen, rather than from that at which


A. MUDIE del.
SEARS Sc.

YEW TREE IN THE CHURCH-YARD AT LEEDS, KENT.

Greatest circumference, 31 feet 3 inches; ditto at 7 feet high, 20 feet 8 inches; diameter of the hollow, 8 feet 6 inches; height to the branches, 7 feet 11 inches; total height, 33 feet 4 inches; spread of the branches, 50 feet.—October 1, 1831.

the effect would be the most striking, and the point of view is much too near, but it is a fixed one, being from the doorway of the belfry tower. In the north, west, and east sides of the trunk there are no openings, and the surface there is almost entirely covered with the little twigs and buds, and their foliage. The south side of the trunk is less verdant, more decayed, and contains the opening already alluded to; indeed, so far as we have examined those ancient hollow yews which have stood so long as to be completely tempered to the situation, and yet have escaped any considerable local casualty or decay, we have invariably found the decay of the trunk greatest on the south side, which shows that the action of the sun is more concerned in bringing about the decay than that of the rain, the snow, or the cold. The form of the head is of course liable to more contingencies, and therefore no conclusion of a very satisfactory nature can be drawn from it; but with equal exposure we have generally found the westward branches to exceed the eastward by a very considerable fraction of their length.

Trees, from their vegetable action and tendency [illegible] being so generally diffused, are always in [illegible], and though the original growth [illegible] one part of the tree often so [illegible] the adjoining parts in vegetation [illegible] the form of a reed, with more [illegible] of circumference. The action of [illegible] to interfere with and [illegible] of other parts, till the growth of [illegible] in all directions—upwards,

the effect would be the most striking, and the point of view is much too near, but it is a fixed one, being from the doorway of the belfry tower. In the north, west, and east sides of the trunk there are no openings, and the surface there is almost entirely covered with the little twigs and buds, and their foliage. The south side of the trunk is less verdant, more decayed, and contains the opening already alluded to; indeed, so far as we have examined those ancient hollow yews which have stood so long as to be completely tempered to the situation, and yet have escaped any considerable local casualty or decay, we have invariably found the decay of the trunk greatest on the south side, which shows that the action of the sun is more concerned in bringing about the decay than that of the rain, the snow, or the cold. The form of the head is of course liable to more contingencies, and therefore no conclusion of a very satisfactory nature can be drawn from it; but with equal exposure we have generally found the westward branches to exceed the eastward by a very considerable fraction of their length.

Yews, from their vegetable action and tendency to form buds being so generally diffused, are always of a branching habit; and though the original growth begins around a pith, one part of the tree often so far gets the better of the adjoining parts in vegetation as to stand out in the form of a reed, with more than a semicircle of circumference. The action of one part seems often indeed to interfere with and confound the action of other parts, till the growth of the stem appears to push in all directions—upwards, downwards, laterally, outwards, and even inwards in the case of hollow stems. This tendency, together with the proneness to form little branches, often produces a very beautiful effect in the wood, which is waved and dotted, and full of eyes, consisting of the branches that are cut right across, at the same time that it is perfectly solid. Before the introduction of fancy woods from other parts of the world, the yew was among the handsomest timbers in Europe for cabinet work; and well chosen pieces from an early trunk in which there is no decay are still reckoned very beautiful. The timber is heavy, compact, hard, and close in the grain; sometimes reddish yellow, and at others bright red brown, and in the gnarled and convoluted portions those colours are blended, and the centres of the strangulated little branches are deepened almost to black. When straight in the grain, yew timber is highly useful for all purposes where strength aud elasticity are required. The importance of that timber for bows in the times of archery has been written about *ad nauseum;* but its modern application to the teeth of wheels and other working parts of machinery, in countries where iron is not so cheap or so easily obtained as in England, is of much more importance. For works that have to stand alternations of wet and drought, and heat and cold, it is not so advantageous, because the same rot which attacks the centres of old stems, when their vegetable action has ceased, necessarily attacks the felled timber. Hard and close as it is, it is much sooner penetrated by humidity than the lighter and less compact timber of the better sorts of pines. That may be inferred from the ease with which yew tree can be dyed; and it is proved by the actual decay of the timber when subjected to alternate wetting and drying.

From the space that it occupies, the small height that it attains in a solid trunk, and the ungainly form of the branches, the yew is not very eminently deserving of culture as a timber tree; and it is not highly ornamental. In small shrubberies it is too gloomy, and soon gets too large, and in forests it is soon hidden by trees of more rapid growth, so that the cultivation of it is not very much attended to.

As the foliage of the yew furnishes a descriptive name for some other species of the coniferæ, it is worthy of being borne in mind. The leaves are of a peculiarly dark and sombre green, of a linear shape, and ranged along the twigs into opposite rows something like the teeth of a comb. The cones or berries are numerous, turn red as they ripen, have their scales united into a soft and clammy pulp of a nauseous sweetish taste, and the seed is lodged in a cleft or hollow at the apex. The berry is, however, a true cone, notwithstanding the peculiarity of its form, and the seed, properly so called, is naked.

A variety of the yew, at least one differing in aspect from the common yew, is found in Ireland; but as the trees are cultivated ones it cannot be considered as a native of that country, and it is, in all probability, accidental.

The other yews that are mentioned are *Canadensis*, which is, probably, the common yew altered by climate; the long-leaved yew of China *(latifolia)*, of which the foliage is not so close as in the common yew; the African yew, of the Cape *(elongatus)*; and one or two others; but too little is known of them to afford any scope for popular description; nor could they be introduced into Britain in any other way than as ornaments.

Of *podocarpus*, the ascertained species are more numerous; but they are all natives of remote countries, and present little matter that can interest the general reader. Three of them, *elongatus*, *coriaceus*, and *macrophyllus*, are natives of China; *verticillatis* is mentioned along with some others in Japan; *neriifolius* is found in Prince of Wales's Island and Nipâl—in the former place it is called the "wax dammar," from its affording a substance like wax, in like manner as the dammara furnishes a pitchy resin; *yacca* is found on the Andes; and also *Chilensis*, further to the south; and *asplenifolia*, in Van Dieman's Land, and *spinulosus*, and probably some other species, in New Holland. All those trees have some resemblance to yews in their habits; and several of them have their foliage so similar as to be styled yews. The qualities of the timber are but little known.

The *dacrydiums* are found only in the South Sea countries; one in New Zealand, and probably another in Van Dieman's Land; but the fact, as to the latter, has not been determined, as the fructification, and especially the seed cone, the only means by which the true character could be determined, have not been observed, although many trees have been cut down for the express purpose.

The New Zealand species, *dacrydium taxifolium*, is a very large tree, having a character something intermediate between a yew and a spruce. It is the *kakataro*, of the New Zealanders; and equals in height the *kawii* tree, being sometimes found more than two hundred feet in altitude. It is a swamp tree, and grows very abundantly on those low banks of the rivers of New Zealand that are flooded during the seasonal rains; and it is very abundant, much more so than the kawii tree. It is also the handsomer tree of the two, and at first attracted much attention from navigators who visited the island, who styled it the New Zealand spruce, and hailed it as likely to be a great acquisition as naval timber, from its size, its abundance, and its proximity to accessible parts of the coast. Those expectations have not, however, been realized in the case of the dacrydium, nor to the full extent in that of the dammara. The last mentioned tree is indeed better timber; but Captain Cruise, who was dispatched by the British government, in 1820, to forage for masts and spars in New Zealand, found that the dammaras were in places too remote and inaccessible, or too dangerous on account of the disposition of the natives, for being profitably got at. In consequence of that he took in a cargo of the dacrydium, with which he returned to England. In December, 1824, a writer in the "Quarterly Review," probably known to Mr. Barrow, whose official connexion with the Admiralty would have been taken, by most people, as a guarantee, either that he would have made himself acquainted with the properties of any timber that was to be used in the navy, or that if he was ignorant he would have enjoined silence, writes thus of the New Zealand timber:—It has been "found on trial to be of equal gravity with Riga spars, and to possess a greater degree of flexibility, as well as of strength, than the very best species of fir procured from the north." It is not very easy for one to preserve "equal gravity" upon reading this sentence, and having, at the same time, the positive evidence of an excellent judge, who examined it again and again on the spot, that dacrydium taxifolium is "perfectly useless timber; the heart becoming rotten almost immediately after it is felled." That the New Zealanders, who, though a rude, are not a silly people, should give every facility for removing the kakataro, which is abundant and useless, and throw every obstacle in the way of the removal of the kawii, which is highly useful to them as their naval timber and by no means either so plentiful or so accessible, is not to be wondered at; but it is somewhat wonderful that the impossibility of obtaining a useful cargo should be held as any sort of excuse for loading a vessel with one that must have been at least half rotten on the homeward voyage. The tree is, however, of some use in the domestic economy of the natives; for they employ it in the manufacture of a species of beer, which is said to have a considerable resemblance to that made from the twigs of the hemlock spruce of Canada.

The tree of Van Dieman's Land, which is considered to be a dacrydium, is the Huon pine, which forms large forests on the banks of the Huon River, and also at some places on the south-west coast of the island. Report speaks more favourably of its timber than of that of the swamp pine of New Zealand; as, however, there are not many lasting timbers in any part of Australia, it is probable that the qualities of the Huon pine are more favourably spoken of than they actually merit.

Phyllocladus, of which there is only one known species *(aspleniformus)*, is a native of Japan, and a plant of singular appearance and habit. The leaves are in the form of those of the *spleenwort fern*, a sort of fan-shaped, but ragged at the outer edge, and with straight vessels. The fruit is described as being about the size of a damson plum, and when roasted it is pleasant to eat. The native name of the tree is *ginkgo*. It has been introduced into this country for more than seventy years. It bears the winter in warm situations; but we believe that it is never either flowered or fruited. In some of its characters it has a considerable resemblance to *podocarpus aspleniformus* of Van Dieman's Land.

Such is a slight sketch of the leading members

Works in a state of forwardness, by the Author of the Botanic Annual.

I.

THE BRITISH NATURALIST, Vol. III.

This Volume, which will contain an autumnal and winter sketch of British natural history, taking the plant or the animal in combination with the scenery and the circumstances, as modified by the season, and by meteorological changes, was intended to be published, and ought in fairness to the purchasers of the former volumes to have been published, before now. The difficulties of some parts of the subject, however,—the necessity of revisiting scenes and reviewing theories,—together with some circumstances over which the Author had no control, have delayed the publication; but as neither the difficulties nor the impediments are of an insurmountable character, it is hoped that the work will be in a fit state for appearing in the course of the present season, and that those who may favour it with their perusal will lose nothing by the delay.

II.

THE BRITISH NATURAL PHILOSOPHER.

A Volume of this work, which was also formerly announced, is in preparation; but though the plan was matured and the execution begun at the time of the former announcement, the labour necessary to carry that plan into execution in such a manner as to be productive of the good which the Author is anxious that it should produce, is much greater than he had anticipated. To explain the principles of physical science is an easy matter, and it is not very difficult to describe their practical applications when both are taken singly; but when so taken each of them is imperfect and unsatisfactory without the other. The object of this work is to combine the principle illustration into one sketch, at the same time that that s descriptive of something which is at once highly society and a striking application of the science—to say, in so far as it is possible to convert, the grand instruments and structures of art in England into one museum of mechanical and chemical science, in which any one may find information amusement, and amusement information, without necessity of calling in the aid either of lecturer or showman. This is, to a very great extent, an untrodden path; and, in entering partly into it, it has proved more beset with obstacles than could have been anticipated. Still, however, it is hoped that one volume may make its appearance in the course of a few months; and when it does appear, the Author will require every allowance to be made for errors and imperfections in an undertaking altogether new and exceedingly difficult.

and the illustration into one sketch, at the same time that that sketch is descriptive of something which is at once highly useful to society and a striking application of the science—to convert, in so far as it is possible to convert, the grand instruments and structures of art in England into one museum of mechanical and chemical science, in which any one may find information amusement, and amusement information, without the necessity of calling in the aid either of lecturer or showman. This is, to a very great extent, an untrodden path; and, upon entering partly into it, it has proved more beset with obstacles than could have been anticipated. Still, however, it is hoped that one volume may make its appearance in the course of a few months; and when it does appear, the Author will require every allowance to be made for errors and imperfections in an undertaking altogether new and exceedingly difficult.